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U.S. DEPARTMENT OF THE INTERIOR
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TERRESTRIAL WILDLIFE INVENTORIES

Some Methods and Concepts

by MAYO W. CALL

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Frontispiece. A trapping array for reptiles and small mammals in Arizona.

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TERRESTRIAL WILDLIFE INVENTORIES

- Some Methods and Concepts -

by

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Denver Service Center

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INTRODUCTION

Public interest in wildlife resources in the United States has greatly increased in recent years. At the same time, increasing human populations have required greater production of basic energy supplies, building materials, and food products to meet their needs, resulting in a variety of conflicts that threaten the survival of some forms of life and the well-being of many others. This has resulted in the need for public land management agencies to expand and intensify programs of data collection to provide adequate consideration of wildlife in all land use decisions. National legislation, such as the Federal Land Policy and Management Act of 1978 (FLPMA), Endangered Species Act of 1973 (ESA), Public Rangelands Improvement Act of 1978 (PRIA), National Environmental Policy Act of 1968 (NEPA), the Sikes Act, Title II (as amended), and Executive Orders (EO) 11988 and 11990 relating to protection of wetlands and floodplain management, have all directed the Bureau of Land Management (BLM) and other applicable Federal agencies to improve management of wildlife and their associated habitats. To meet wildlife needs in the face of ever-increasing complexities in land management programs and increasing demand for public lands resources, more and better information on all resources is now required than ever before.

Inventory programs for land managing agencies are not just simple information-gathering programs but have as their primary purpose the gathering of information needed by land managers to make sound management decisions. To accomplish this function, inventories must be planned well in advance, with well-defined objectives in mind. Once baseline data has been gathered on the various resources, then monitoring studies conducted in future years will reveal to the land manager the effects of various land use decisions.

Ideally, both inventories and management would be conducted on an ecosystem basis, rather than on separate components or species. Basically, all land areas are comprised of unique biotic and abiotic components which interact in specific ways to allow the perpetuation of the renewable resources, such as animals and plants. Unless disturbed by man, extremes of weather, or other forces of Nature, most ecosystems exhibit a reasonable degree of stability, even though fluctuations in biotic populations occur from time to time because of various intrinsic factors. Important interrelationships often cannot be discovered without some reasonable knowledge of each component within the system. Biologists may have differing opinions on the structure of various ecosystems, but we should continue to work toward defining and delineating the ecosystems found on the public lands and work toward monitoring methods and management systems that will assure their integrity and perpetuation.

Land and its inherent products can best be managed when we have a clear view of the role of each of the components and their relationships to each other. Too often, we attempt to manage, control, or exploit individual plant or animal species (or other resource components) with almost no knowledge of, and sometimes little regard for, the potential

effects on other forms of life. And, too often, we state that we have too little time to uncover the basic natural relationships within an area before we commence large-scale "development" or manipulations of resources to meet mankind's immediate needs. While the production of many basic products, such as food, fiber, and energy must continue on a regular basis, there are many other products of the land that may be harvested more slowly and systematically with little inconvenience to the human race. Careful planning and less use of the "most expedient means" should be exercised for resource development whenever time permits. Actual human needs, not profit motive alone, should dictate the means and rate of utilization or exploitation of the earth's limited and often fragile resources. Perpetuation of a reasonably natural environment is the key to the enjoyment of human life upon the earth and perhaps the requirement for its very existence. Hence, we need to determine the status of this nation's various resources, so that we may have the information needed for making "sound management decisions."

The first step in identifying the roles played by the various components of ecosystems is to determine the names, numbers, and locations of the players. In other words, we must conduct baseline studies to find out what we have to work with. And,...since we do not have funds or manpower to inventory all areas at once, we must first determine where the priorities lie. Defining land management issues or determining where the major conflicts in resource uses occur will help establish priorities for inventories. This definition of problem areas commences with the preplanning portion of the Bureau's planning system. During pre-inventory sessions, the level or detail of information needed for wildlife should be determined. The nature and intensity of the conflicting uses will largely dictate the amount and kind of data needed to resolve the issues involved. Priority areas for collecting wildlife information will be generally as follows (not necessarily in order):

1. Habitats containing endangered, threatened, or sensitive species (both Federally and State-listed).
2. Habitats containing game and/or commercial species.
3. Areas of special environmental concern.
4. Areas of existing major conflicts from existing land uses.
5. Areas of expected high conflicts from proposed land uses.
6. Habitats of all other wildlife, as time permits.

Two basic components need to be inventoried and evaluated for the wildlife resource: (1) the animal habitats, consisting mainly of the soil, vegetation, water, and space (including topography and landform) utilized by the animals, and (2) species occurrence and some measure of abundance for the animals using the different kinds of habitats. BLM Manual Section 6602 basically describes a system for classifying and tabulating data on the above categories, after it has been collected using a random or systematic inventory procedure. BLM Manual Section 6602 does not prescribe any standard procedures for collecting the data but does provide an orderly system for tabulating the data by specific habitat "types," or sites. BLM has a system for

describing "standard habitat sites," which are specific areas of habitat that are represented and defined by the predominant existing vegetation types and the local landform. This is in contrast to the U.S. Forest Service, which uses "habitat type," meaning a site which has the potential for producing a specified "climax" or potential type of vegetation, given the existing soils and climate.

In this Technical Note the author has incorporated ideas on wildlife inventories from a wide variety of sources. Some ideas were quoted directly from various publications, while others were derived from discussions with several authors and researchers. The author has presented a few ideas and concepts on a wide variety of species. From this the inventory specialist can hopefully glean some ideas and then develop procedures to fit his/her particular situation. While it is deemed important to obtain baseline data on existing wildlife resources to aid in making day-to-day land use decisions, it is equally important to monitor the effects of these decisions on wildlife populations and their habitats. Such monitoring is simply re-sampling, or re-inventorying, through time. The inventory procedures discussed in this publication can be utilized for this purpose.

In reviewing the literature on inventories (including surveys and censuses) for any group of animals, it soon becomes obvious that two separate researchers seldom use precisely the same techniques in conducting their inventories or research. While they usually follow basic established sampling principles, they will often modify the sampling design to meet their specific objectives, as well as time and funding constraints. Differing experiences and knowledge on inventory procedures naturally bring about different opinions on the most productive procedures to use. For example, most small mammal trappers use some kind of bait in their traps, while a few skilled mammalogists can produce highly effective results without using any bait. Obviously, trappers who use no bait must be more intimately familiar with the behavior of the species sought, and microhabitat preferences, than those who use bait to draw the animals to the traps.

In conversing with inventory specialists and experienced researchers, the author has heard many tales about wide variations in inventory or census results that are largely unexplainable, based on our present understanding of animal behavior and population dynamics. Trapping results, for example, have shown great fluctuations from night to night or year to year in the same habitat site. Birds noted on a census plot in two consecutive mornings have varied considerably, even though the apparent weather and other conditions have seemed to be virtually identical. From this, we conclude that all animal life is very dynamic and that we should not expect all animals to respond exactly the same from day to day. Differences in their behavior or detectability may be occurring because of subtle environmental changes or internal physiological changes of which we are not even remotely aware. Therefore, in arriving at inventory results, we usually state that the findings are what we obtained for that specific time and conditions, and that

applying these results to other areas and times may be somewhat uncertain. We hope the sampling results will be representative of species and populations found throughout that particular kind of habitat, and we make this assumption in applying the sampling results to broad areas of similar habitat. Let's keep in mind, however, that unexpected fluctuations in species and populations do occur in nature from causes not immediately discernable to the human senses. There is much yet to be learned about animal behavior and animal sensitivity to environmental changes. Continued inventory data accumulation with concurrent analysis of conditions present at the time of the inventories will help answer many questions.

This Technical Note primarily discusses some methods for obtaining data on species occurrence and relative abundance, with some additional information on surveying special habitats as they relate to the presence of selected groups of wildlife. A section on Selected References is included to aid the reader in finding references on philosophies and methods in their special interest areas.

BLM SOIL AND VEGETATION MAPPING PROCEDURES (SVIM)

The Soil-Vegetation Inventory Method (SVIM) is the Bureau of Land Management's (BLM) method for conducting basic soil and vegetation inventories (BLM Manual Section 4412). As part of this inventory procedure, all areas are mapped to show both potential plant communities (range sites) and existing plant communities (site write-up areas or SWA's). These SWA's are analogous to individual habitat sites as described in BLM Manual Section 6602. The existing plant communities are broken down further into condition classes which are defined as the seral stages of the existing vegetation. The criteria for mapping the existing vegetation communities are: vegetation species composition, ground cover, height, and age class; topography; and any other factor identified in the inventory plan.

A SWA should consist of a fairly homogeneous existing vegetation type in the same seral stage. If such mapping has not been completed for the area by a mapping team, the biologist may use aerial photographs (1:24,000, if available) to delineate the more obvious areas of fairly homogeneous vegetation. Ground-truthing will be required to check the preliminary mapping results and to make minor adjustments. It is desirable to have all areas mapped, using the above-listed criteria, prior to commencing wildlife sampling for species occurrence and relative abundance.

RELATIONSHIP OF SVIM TO WILDLIFE INVENTORY PROCEDURES

Biologists should sample for species occurrence within the delineated SWA's. By so doing, all other data pertinent to a particular SWA can be correlated with the wildlife species found there. Insofar as they are applicable, these mapped units should be the basic sampling units for all resources. If the formal SVIM inventory has not been accomplished for any given unit of land, the biologist can describe standard habitat sites (SHS's based on homogeneous vegetation and landform), delineate the area of concern into different habitat sites, and then commence to sample (inventory) these habitat sites. All habitat sites having similar vegetation, soil, and topographic characteristics are considered to be the same standard habitat site. In other words, the habitat sites are stratified by similar characteristics. The "stratification" of SWA's simply means the grouping of mapped areas that have similar characteristics. The implication is that areas having similar floral, soil, and topographic features should also have fairly similar fauna within the same general locality. Obviously, no two areas will be identical, but they may be similar enough to be expected to have approximately the same species of wildlife.

Procedures for describing SHS's in any land planning unit are prescribed in BLM Manual Section 6602. The SHS's are named according to the predominant vegetation species and the local landform. Emphasis should be placed on an early identification and description of all SHS's in each state. Once these descriptions are completed for any state or district, then all areas may be classified and mapped as being one or another of these SHS's. In general, the stratified SWA's (all SWA's grouped together that have the same common characteristics) are essentially the same as standard habitat sites that will be used by the biologist. This will be more true if a biologist were a member of the SVIM mapping team and insisted on mapping SWA's to include some of the important physical characteristics for wildlife (such as landform, aspect, elevation, and slope). In the Southwest, landform and aspect tend to be of lesser importance since the same vegetation may grow on all aspects and types of terrain due to greater temperature and precipitation uniformity.

During the SVIM data-gathering process, considerable information on soils and vegetation will be collected that will be useful to biologists. By looking at maps showing the delineated SWA's (existing vegetation), biologists can obtain a good indication of the kinds of species of animals that may be found at each site. This will be especially true after some of the stratified SWA's have been inventoried and data is in hand showing the observed animals. For example, certain species of animals (birds, small mammals, reptiles, amphibians) will be found to be somewhat habitat-specific for big sagebrush areas, while other species will be largely habitat-specific for pinyon-juniper stands or old growth forests. Many species of birds will be found to prefer certain kinds of riparian vegetation and will vary in species composition, depending on whether the predominant vegetation is aspen, cottonwood, sycamore, willow, hemlock, sedges, grass, bulrush, or some other type. Much of this species occurrence information can be obtained from literature reviews, but only on-the-ground fieldwork can verify their presence for the specific area of concern.

If the SVIM procedures are conducted as specified in Manual Section 4412, biologists will be able to stratify the data in a variety of ways to aid them in the search for important interrelationships between the wildlife and the existing soils, flora, and other habitat characteristics. Various wildlife species will be found predominantly on level ground, while others will tolerate a wide range of slope steepness. Other species will prefer certain aspects or exposures (south, west, etc.), while some species will seem to prefer light canopy cover, as opposed to heavy canopy cover. Once these kinds of data are obtained, either through the SVIM process or separately by the biologist, they can then be analyzed and applied to unsampled (for wildlife) areas. To have this predictive capability, sampling must be accomplished in fairly homogeneous stands of vegetation, both as to floral species composition and as to other key habitat characteristics. Brewer's sparrows, for example, have been found to nest predominantly in sagebrush stands of certain heights.

ANIMAL COMMUNITIES OF STANDARD HABITAT SITES (SHSs)

While many species of animals live in a wide range of habitats, most of them are closely tied to specific kinds of habitat during important phases of their life cycles. We expect to find certain kinds of animals and birds in any specific type of habitat that we look at. Birds, for example, will be found nesting predominantly in certain kinds of sites, and we learn to look for their nests primarily in those kinds of sites, not indiscriminately in all kinds of vegetation or in all kinds of habitats. An example is the avocet, which is found nesting predominantly around some type of surface water while an exception is the robin, which we might expect to encounter in almost any kind of habitat--from forest to prairie.

The animal communities of all habitat sites that are designated as being within the same described SHS should be reasonably similar. Highly mobile animals and birds from adjacent but different habitat sites may be found in several sites because of their high mobility, but will spend most of their time in their most preferred habitat.

SPECIAL HABITAT FEATURES

Many different kinds of special habitat features, such as caves, cliffs, snags, talus slopes, etc., are listed in BLM Manual Section 6602. The location of these features should be recorded as part of the SVIM inventory. Each of these special habitats have unique species of animals (birds, bats, reptiles, etc.) that are dependent on them and need to be inventoried separately from the broad habitats in which many of them are located. Inventory methods for the fauna will vary with the kinds of creatures expected to be present in the different features for various regions of the country. At least 10 percent of the features of each type should be sampled to have fair predictive capability for species expected to be found in the sites that are not inventoried. Because of the uniqueness of the fauna inhabiting such sites, they should be provided special management and/or protection in land use decisions.

THE LIFE FORM CONCEPT

Thomas et al (1979) define life form as "a group of wildlife species whose requirements for habitat are satisfied by similar successional stages within given plant communities." The species exhibit similar habitat requirements for both feeding and reproduction. If one wishes to use the life form concept for management purposes, he must (1) list all potential life forms for feeding and reproduction in the management area, (2) inventory all animal species in the area and place them in one of the described life forms, and (3) select representative species in each life form on which to base management decisions. There may be 30 or 40 species (or more) in any specified life form. The concept is based on the assumption that all species assigned to a particular life form will respond approximately the same as the representative species to any changes in their habitats. Hence, by observing the responses of the representative species to changes in seral stages in the vegetation or to other land uses, we will have a good idea of the general effects on all species assigned to that life form and will not have to monitor or be concerned about each separate species within that life form. The premise for this concept is well-founded, because in reality there is no way we can monitor every species that might be affected by various land uses.

The concept as used by Thomas et al. (1979) is for managed forests in Oregon and Washington. Vegetation changes created by timber management, including timber harvest, are easier to discern than gradual changes that may occur on rangelands as the result of livestock grazing or other uses, but nevertheless, these subtle vegetation changes do cause changes in the composition of the wild fauna. The land manager's job will be to learn to identify the faunal changes that occur with changes in range-land vegetation and then to decide what vegetation composition and structure are optimal for the desired faunal community. Any authorized land use will produce various changes in vegetation in different parts of the use area; results will not be uniform; the objective will be to produce an average effect over the entire use area so that the needs of the desired fauna generally will be met.

GUILDING CONCEPT

A guilding analysis method is being developed and tested by the U. S. Fish and Wildlife Service, in cooperation with the BLM. This is an analysis method for graphically and statistically describing animal relationships within an ecological community. It is based primarily on vegetation structure and the fauna normally found within each structural level. The method may have merit for: (1) enhancing efficiencies in selecting animal species for habitat inventories; (2) evaluating habitat quality; (3) developing management options for wildlife; (4) predicting long-term changes in habitat quality and animal-habitat relationships;

(5) performing regional assessments of wildlife resources; and (6) identifying data needs for these analyses. Testing and evaluation of the method will probably require a minimum of two years, starting in the spring of 1981.

BLM POLICY ON COLLECTION OF WILDLIFE DATA AND ANIMAL SAMPLING

State wildlife agencies have generally accepted, or at least acknowledged, the proposition that Federal land management agencies, e.g., U.S. Forest Service and BLM, are primarily responsible for managing wildlife and fisheries habitat and the State wildlife agencies have primary authority for managing species. Under certain instances the U.S. Fish and Wildlife Service has species jurisdiction.

State wildlife agencies often have very limited baseline data for both game and nongame species in specific areas of Federal concern. Where this has been the case and when the wildlife species information is needed for proper planning and decision making the Federal agencies' biologists have often collected the information to make certain the information is available for timely decisions. Given short time-frames for making management decisions, this method must continue to be one of the options for gathering species information.

Collecting species and population data by Federal agencies must be closely coordinated with the concerned State wildlife agency. Need for the data, time-frames involved, and options for gathering the data should be fully discussed and explored with the appropriate State wildlife personnel.

Suggested procedures for obtaining species occurrence and relative abundance information are as follows:

1. Contact State wildlife agencies, U.S. Fish and Wildlife Service, U.S. Forest Service, State universities, museums, and state and local conservation groups and obtain all information available on species occurrence and relative abundance for the specific area of concern.

2. Program funds for data gathering if information is not available from other conservation organizations and if time permits. Funds may be requested for conducting inventories with personnel within the Bureau (or hiring additional personnel) or for the procurement of the needed information from outside sources, such as State wildlife agencies, universities, U,S. Fish and Wildlife Service, conservation organizations, consulting organizations, or private individuals. If the decision is made to contract with an outside source, the contract should be awarded to those who: (1) are most knowledgeable on the species and habitats to be inventoried, (2) are able to meet the prescribed time-frames, and (3) will do the required work at the lowest cost. The lowest estimated cost becomes an important criterion only after it is determined that the prospective contractor is qualified and able to perform the required job. Pertinent Department and Bureau procurement regulations, policies, and procedures must be followed.

3. Notify the State wildlife agency concerning who will be conducting the inventories. They should be provided with copies of the information obtained at no cost. Copies of the inventory data should also be provided to the U.S. Forest Service and U.S. Fish and Wildlife Service to ensure good public relations and to comply with recent Memorandums of Understanding.

4. Notify the State wildlife agency if it is decided to conduct the needed inventories using in-house Bureau personnel. Request any available assistance from the State in gathering the data and request and obtain any required permits from the State and the U.S. Fish and Wildlife Service.

PERMIT REQUIREMENTS

Several Federal laws provide protection to wildlife and require special permits for "taking" any of the protected species. Laws included are the Bald Eagle Act of 1940, with subsequent amendments; the Endangered Species Act of 1973; and the Migratory Bird Treaty Act, which on March 10, 1972, was amended to protect all raptors and all migratory birds between Mexico and the United States. The term "taking" under some of these acts includes any acts of harrassment, disturbance, or possession of the birds, or any disturbance of nests or the young.

Many states also have specific laws protecting all or certain groups of wildlife, especially furbearers, game species, and endangered or threatened species, but sometimes also including many nongame species. These laws may require anyone, including Federal employees, to obtain the appropriate permits before any of the protected species may be "taken" or disturbed.

Before any inventories are started that require the trapping, netting, shocking, or other sampling methods that may kill or do other physical harm to wildlife (including fish) or that in any way might be construed as "taking" protected wildlife, both the State wildlife agency and the U.S. Fish and Wildlife Service should be consulted. They will advise you on the kinds of permits that should be obtained for the specific kinds of inventories that you plan to conduct.

INVENTORY LEVELS AND STANDARDS

During the preplanning analysis, usually at the District level, the biologist will determine the information needed for management decisions as related to the wildlife aspects of the basic land management issue(s). The inventory level will also be determined during preplanning and will be related to the issues involved, the key species of wildlife or their habitats that may be impacted, as well as related to work-months and funding constraints.

Inventories are conducted to fill in information gaps and to provide wildlife species and habitat data that are not available from other sources. Insofar as is possible with the work-months and funding available, wildlife species and habitat information should be collected so that the data can be statistically evaluated, which will be especially important when controversial issues are involved and will require well-thought-out inventory designs that may require a statistician's assistance. It is recognized that funding may not be available to do this.

Information Needs and Sampling Intensity

The kinds and degrees of information needed for any given area will depend on the land management issues or controversies involved; therefore, each situation will be different. Some inventories will cover broad areas, while others will be intensive inventories of all existing wildlife and their habitats on small areas that are likely to be highly impacted by proposed land uses. However, high intensity inventories can seldom be justified unless endangered, threatened, highly sensitive, or very unique species are suspected to be in the area. If all species concerned are believed to be just run-of-the-mill species that probably exist over vast acreages, there is little reason to conduct intensive inventories, as general extensive inventories will probably suffice. Some researchers will argue that all areas should be intensively inventoried to be sure we are not overlooking rare subspecies or other very unusual species, but from the practical standpoint the Bureau is not adequately funded to do this.

The establishment of standard levels of inventory for sampling vertebrate species of animals is very difficult, primarily because several different species within the same unit may be of varying importance and would, therefore, require different levels of information. Even if we suggested that the lowest level of inventory be a complete review of the literature pertaining to wildlife in a specific area, we would still find great differences in the amount of data obtained. Some areas have been studied in great detail, with accompanying published reports, while other areas have had virtually no studies. In areas where the wildlife species and their habitat requirements have been studied and reported on, a thorough literature review might produce satisfactory information

for decisionmaking. If no studies or surveys had been conducted within the area, a literature review would be worthless. Also, the species of immediate concern may not have been studied at all, while other species, not of any present concern, may have been studied in detail.

Most BLM districts conducting vertebrate inventories will be dealing with hundreds of terrestrial species. In an effort to simplify the problem, the biologist will break these species into major classes, i.e., birds, reptiles, amphibians, mammals. Yet, each of these groups must be further divided for inventory purposes since different methods must be used. For example, raptors, colonial waterbirds, upland game birds, and song birds all require different inventory techniques if satisfactory information is to be obtained. One need only compare the International Bird Plot Census Method (spot mapping method) used for song birds with the strutting ground counts used for sage grouse to illustrate the point. Also, some animals can be observed during the daytime while others come out only at night. Thus, a standard system of spring daylight observations could work well for northern plateau lizards, but not at all well for night snakes or Gila monsters.

Animals whose range is questionable, such as the western yellow bat in southern California, might be intensively sought to establish its range, while the ubiquitous western fence lizard would receive very little attention. If forage allocation in an allotment is being completed, or monitoring of an allotment management plan is taking place for future adjustments, it is imperative that we have a good estimate of the population of elk so that appropriate adjustments can be made for both livestock and elk. In the same unit, a very intensive inventory of black-throated sparrows and rock squirrels would be of virtually no value in making the management decisions. An endangered rodent species would receive a higher level of inventory than a very common rodent. It is obvious, then, that species of high interest will receive the greatest attention.

Lacking any better solution, the author has included a modified table from BLM Instruction Memorandum 79-391, dated April 11, 1979, that can be used as a general guideline for planning purposes (Table 1).

Data Elements

The term "data elements" refers to the actual end products derived from various resource inventories. For data to be aggregable, or comparable, all field units should use the same terms. Kinds of data elements would include such products as animals trapped per trap night (or 100 trap nights) by species, birds per 100 acres by species, reptiles per acre by species, etc. Some data elements are suggested for different kinds of wildlife in following sections, but these are not approved as standard by the Bureau. This will require additional coordination. Where sampling for species occurrence and relative abundance is to be accomplished, the biologist should confer with State universities or State wildlife agencies to work towards common terminology.

Table 1. Inventory Levels, Descriptions, Uses, and Data Sources for Terrestrial Wildlife Inventories. (adapted from BLM Instruction Memorandum 79-391, dated April 11, 1979, from Washington Office)

LEVEL	DESCRIPTION	USE	SOURCE
I	Collecting existing information and some field reconnaissance (no measurements or sampling).	For nonsite specific uses, as well as for low and medium intensity EARs.	Literature, museum records, State wildlife agencies, recognized experts, opportunistic field observations.
II	Minimum field sampling (systematic measurements during the two seasons expected to yield the best wildlife information); minimum of two habitat sites sampled per SHS. The number of transects, plots, or other sampling to be done for each habitat site should be based on acreages and observed variability within the habitat sites.	Minimal for land use planning; site-specific EARs and ESs not involving high wildlife values or controversial wildlife issues.	Same as Level 1, plus sampling of at least two habitat sites (i.e., SWA's) per SHS (i.e., stratum).
III	Moderate to intensive field sampling (systematic measurements during all seasons). The number of transects, plots, or other sampling to be done for each habitat site should be based on acreages and observed variability within the habitat sites.	Preferred level for land use planning; minimal for major EARs and ESs involving high wildlife values and/or controversial wildlife issues.	Same as Level 1, plus sampling of four or more habitat sites per SHS (or stratum).
IV	Multi-year statistically reliable sampling (includes a number of years and seasons).	Thorough baseline monitoring and in-depth analyses of specific major management problems.	Develop Level 1 data; then conduct intensive sampling (more transects than Level III) to obtain results within predetermined confidence intervals.

Species Occurrence

The term "species occurrence" merely refers to a listing of all wildlife species found to occur in various seasons in different habitat sites. BLM Manual Section 6602 suggests the inclusion of species for which verification is lacking but whose presence is likely. However, hypothetical species should be based on well-founded conjecture. Literature reviews, museums, and both amateur and professional field people can provide considerable information on potential species in specific habitats and areas. Development of listings of species by SHS's will greatly aid in determining species present in unsurveyed areas where sampling may not be possible, or minimal at best, and where rapid evaluations of potential impacts from proposed projects or land uses are required.

Relative Abundance

Relative abundance refers to the relative number of animals of each species in comparison to the total number of individuals for all species. Terms, such as "abundant," common," or "rare" are often used to express the general population status of a given species, but such terms are most useful when tied to something that is measured or estimated in a manner that makes comparison meaningful. These terms when used should be defined in terms of the local situation or abundance. Actual values may be expressed in relation to ratios or as percentages of the total, or in other ways. BLM Manual Section 6602 prescribes the use of six relative abundance terms: abundant, common, occasional, uncommon, rare, and seasonably absent. Table 2 shows relative abundance definitions prepared and used by the Phoenix District of the BLM. Their meanings are fairly clear, since they relate to specific habitats or localities within the district.

Diversity Index

The distribution of numbers of individuals (or other quantities such as biomass or productivity) among the species of a community has long been regarded as great importance in studying the organization of the community (McIntosh, 1966). Hairston (1959) stated that ..."numerical abundance and spatial distribution of all species must be taken into account before an understanding of community organization can be obtained." Plant ecologists have usually used a subjective estimate of similar appearance and composition to assess homogeneity, but in a stricter sense a plant species is considered homogeneously distributed if the mean number of individuals is the same in all parts of an area, i.e., if the probability of encountering the species is the same (McIntosh, 1966). Two thought-provoking articles on the concepts of diversity have been published by McIntosh (1966) and Pielou (1966).

The diversity index is the ratio between the number of species and the number of individuals. Severe limiting factors result in a low diversity index; thus, arctic tundras and salt lakes have few species

Table 2. Definitions of Relative Abundance Terms as Defined and Used by the Phoenix BLM District.*

FISH

A - High capture rate during electroshocking or gill netting.

C - Moderate capture rate during electroshocking or gill netting.

U - Low capture rate during electroshocking or gill netting.

N - Extremely low capture rate during electroshocking or gill netting.

AMPHIBIANS AND REPTILES

A - Herptiles which are ubiquitous throughout many habitats with high frequency of verification.

C - Herptiles occurring in moderate to high numbers in a few to several habitat types with a moderate frequency of verification.

U - Those herptiles with small population numbers and/or habitats that result in few visual verifications. May occur in only a few habitats but not necessarily.

R - Those herptiles which have extremely small and isolated populations often keyed in on one or two habitats and/or special physical features of each habitat. Almost never encountered.

BIRDS

A - Species is almost always seen in large numbers.

C - Species is usually seen in numbers in suitable habitat.

U - Species is not often seen but is not out of normal range.

R - Species is very infrequently seen in the study area or is out of normal range.

T - Species only occurs in study area during periods of spring and/or fall migration. Also applies to species that may occur as wanderers.

MAMMALS

Big Game

A - Very likely to be seen in large numbers every time by a person visiting its habitat at the proper season.

C - May be seen most of the time or in smaller numbers in its habitat at the proper season.

U - May be seen quite regularly in small numbers in the appropriate environment and season.

R - Occupies only a small percentage of its preferred habitat or occupies a very specific limited habitat.

Small Game and Nongame

A - Frequently observed or collected in numbers.

C - Often observed or collected.

U - Infrequently seen or collected, present in low numbers.

R - Seldom seen or collected, present in very low numbers.

SC - During one or more seasons in a year usually common in the same season.

SA - During one or more seasons in a year usually abundant in the same season.

*A = Abundant
C = Common
U = Uncommon
R = Rare
N = Extremely low capture rate for fish
T = Transient
SC = Seasonally
SA = Seasonally

but often large numbers of individuals. At the opposite extreme, a tropical rain forest with its numerous niches may have a very high diversity (Odum, 1968).

Where there is a high diversity, the observations are evenly distributed among the various species. A habitat possessing a low species diversity has most of the observations occurring in one or only a few species. Generally speaking, habitat stability and complexity increase with increasing diversity (Franzreb, 1977).

Measurements of plant and animal species diversity, one of the most important aspects of community structure, provide an overall estimate of the variety or number of species (species richness) and their relative abundances (evenness of distribution), expressed in mathematical form as an index. The following information relative to diversity indices has been extracted from an excellent discussion on the subject in a draft manuscript from the Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Fort Collins, Colorado, entitled: PROBLEM ANALYSIS -- Ecological Analysis Techniques for National Assessments of Wildlife and Fish.

Hair (in press) suggested that the following seven major criteria must be considered before selecting a certain method for collecting data and calculating a diversity index:

1. The spatial boundaries of the area containing the community, the way in which sampling was conducted, and the time limits during which observations were made must be specified.

2. Measurement of diversity requires a clear taxonomic classification of the subject matter. Reference in the literature is usually made to species diversity, but nothing precludes treatment of any taxon rank, structural components of the habitat, or even trophic diversity.

3. All individuals assigned to a specific class are assumed equal. Different forms (e.g., sexes, age classes) of the same species may have very different functional roles in the structure of a particular community.

4. All species are assumed to be equally different. The assumption of species equivalency is questionable and it is suggested that a factor for weighting individuals by reproductive value be used for calculating species diversity.

5. Most diversity indices require an estimate of importance. Abundance is not always the best indicator of a species' importance. If possible, data should be weighted by appropriate conversion factors (e.g., biomass, dry weight) before comparisons are made.

6. Many plants and animals are not distributed randomly throughout a given area or sample. This necessitates careful randomization or stratification in sampling and correct use of statistical procedures (e.g., parametric versus non-parametric).

7. Three levels of diversity have been distinguished:

   a. alpha diversity (within-habitat or intra-community diversity)

   b. beta diversity (between-habitat or the change in species composition along environmental gradients), and

   c. gamma diversity (diversity of the entire landscape which is a composite of alpha and beta diversity).

These forms are not always easily distinguished.

The interpretation of diversity indices is a major problem. For example, two or more sets of data could have the same relative abundances of totally different species and have identical diversity index values. Also, two areas could provide suitable habitat for identical species but have different diversity indices because of species population changes that shifted the equitability component without modifying the number of species present.

Certain community (habitat) properties such as vegetative characteristics, structural features, and size have been shown to be important factors in determining avian species diversity of terrestrial habitats. Finally, from a wildlife management standpoint, habitats with high diversity indices are considered to be more "desirable" for wildlife than those with lower indices. However, although the creation of maximum habitat diversity for a particular community will benefit many wildlife species, it may exclude others which might be uncommon, threatened, or endangered.

In general, the concept of diversity and the desirability of maintaining diversity of ecosystems is supported by ecologists. However, diversity indices are difficult to interpret biologically and there is disagreement among ecologists as to which of the many methods available for calculating diversity indices provides the most accurate estimate of habitat and/or species diversity.

Biologists should make an effort to analyze faunal diversity in the various vegetation communities in which they are working and to obtain a better understanding of the interrelationships between the animals and plants that are inherent in the various communities.

Density/Population Estimates

In practical land management we seldom determine the actual density of any animal population within a given area. We usually estimate density based on population sampling. During inventory preplanning stages the biologist should decide on the need for density or population estimates for any species or groups of animals in the area of concern. There is probably little value in conducting the necessary sampling to make estimates of density/population for most of the rodents, because their populations may be irregularly cyclic or may fluctuate greatly in short periods of time because of adverse or favorable weather conditions, food supplies, intrinsic factors, or for other reasons. Trying to correlate their numbers with some land use could be very frustrating because of many potential causes. However, if, for example, there is a special need to estimate the total biomass of prey available to a specific raptor population or for some similar purpose, spending the required funds, manpower, and time may be adequately justified. The potential impacts of many proposed land uses on small animals are usually not considered high enough to justify high intensity sampling, especially where only "common" species are believed to be involved.

The presence or absence of sedentary species and their estimated relative abundance are usually adequate for most land management decisions. On the other hand, if we are very interested in the changes in fauna resulting from various land management activities, we must then conduct adequate inventories to obtain good base data to use to compare against later data. Species occurrence for birds if used by itself would have little meaning, since many land uses could drastically reduce numbers of various species while still allowing the survival of a few of each species. Species lists, by themselves, tell us little about population impacts. If land managers are to know the impacts of land use actions, control areas must be established within reasonable distance of the treated areas and in the same vegetation type, structure, density, etc. Birds (or other species) could be monitored on both the test and control areas to determine the effects of the land use. Many environmental factors produce population fluctuations on a seasonal or annual basis. Changes in bird numbers could unjustifiably be attributed to a land use activity unless a control area were available for comparison. Gradual, long-term changes in bird species composition or numbers would indicate to the land manager the effects of his land use decisions.

HABITAT DESCRIPTIONS

A description of the vegetation and other habitat features at each animal inventory site is very important. Vegetation species composition, percent ground cover, shrub understory type, canopy coverage, etc., can be very important in analyzing habitat requirements for various species or life forms. Data obtained during SVIM inventories is minimal. Methods for vegetation descriptions may be found in many of the better animal journals and should be used if the species occurrence and relative abundance data are to be properly analyzed. Features, such as landform, topography, elevation, slope, aspect, soils, and other special habitat features, should be described. The periodical, American Birds, contains good examples of habitat descriptions for bird inventory work.

MAMMAL INVENTORIES

Sampling procedures for determining species occurrence and relative (or absolute) abundance are more suitable for use with relatively sedentary species than on mobile species. The larger mammals, such as deer and elk, are generally not randomly distributed throughout an area; they are creatures of habit, which means they may use the same area year after year, even though other habitats close by may appear just as suitable. Animals classified as "big game" are usually clumped, especially during winter, and must be inventoried or located by examining all suitable areas in the various seasons. Some areas that appear to biologists to be highly suitable habitat for deer, elk, or other species are seldom used by these animals for one reason or another.

Most of the large predatory mammals, such as coyotes, bobcats, mountain lions, and bears, range widely; hence, their presence is more likely to be detected by random sampling methods. Even so, searching their most desirable habitats will more likely reveal their presence.

Rodents and Lagomorphs (rabbits) are considered to be relatively sedentary (live in small areas) and are more likely to be randomly distributed across homogeneous vegetation types. Therefore, animals found in any specific habitat site will probably be very similar to the numbers and species of animals found in the same kinds of habitat sites in nearby areas (or, in many cases, in distant areas). The predictive capability for animal occurrence and abundance is more applicable for the smaller, sedentary species and less reliable for the larger, more mobile species.

A few data elements that might be considered for the various mammal groups are as follows:

For big game (deer, elk, moose, bighorns, antelope, mountain goats, caribou, bison, etc.):

1. Total estimated number of animals for each species by herd unit.

2. Total estimated number of animals for each species using public lands in each resource area by season.

3. Estimated number of animals by species and season using each grazing allotment.

4. Estimated number of animals by species and season using each grazing pasture.

For large carnivorous mammals (coyotes, bobcats, foxes, mountain lions, bears, wolves, etc.):

1. Estimated number of each species per square mile.

2. Estimated number of each species in each resource area.

For rodents and lagomorphs (rabbits):

1. Estimated number of rabbits by species per square mile, or per acre.

2. Number of rodents of each species taken per 100 trap nights.

3. Estimated number of each species of rodent per acre (sometimes calculated for intensive studies on a site-specific basis).

For bats:

1. Species occurrence and total number captured of each species.

For shrews and moles:

1. Estimated number of each species per trap or pitfall night.

Methods for determining species occurrence and/or relative abundance for the various animal groups are as follows:

1. Big game (Large Mammals)

   Indications of species of large mammals in an area include the following:

   a. Actual observations of the animals within the area.

b. Pellets (droppings) that can be identified as being a particular species.

c. Tracks that can be identified.

d. Road kills of particular species.

e. Hunter harvest of various species.

f. Miscellaneous signs: dropped antlers, shed hair, rubbed trees, wallows, elk bugling, etc.

Direct counts of some species are used in making population estimates, particularly in winter for antelope, bighorn sheep, elk, and moose. Aerial observations are especially useful in winter when animals are concentrated on winter ranges. Helicopters and fixed-wing aircraft can also be used to good advantage in summer to estimate antelope, mountain goat, and bighorn sheep numbers. Terrain, cover, and weather conditions all affect aerial counts and animal visibility.

On a particular range pellet group abundance from one year to the next, tracks, and road kills may all be used as trend indices. Like jackrabbits, deer are assumed to be more abundant when the number of road kills increases. Numbers of pellet groups are also utilized in making population estimates for specific ranges, since the defecation rate for each species is pretty well known. However, there is considerable variation in rates of decomposition of pellets caused by dung beetles and weather in different parts of the country, as well as variations in visibility of the defecated material in different kinds of vegetation. Some difficulty may also arise in differentiating among droppings of deer, domestic and bighorn sheep, and antelope where they use the same ranges. Use all of these indices with some degree of wisdom.

2. Large Carnivorous Mammals (Predators)

Some methods used for detecting the presence and relative abundance of predators, such as badgers, ringtails, bobcats, coyotes, lynx, bear, mountain lion, etc., include:

a. Observing tracks that are identifiable.

b. Identification and abundance of scats.

c. Number of trails coming in to scent stations and identifying visitors.

d. Interviews with local trappers and other outdoorsmen and search of available literature.

e. Nocturnal searches along roads using a spotlight to detect eyeshine.

f. Use of predator calls (voice calls, tape recorders, and/or special predator calls and bugles or sirens) and listening for responses.

g. Trapping for specific species.

3. Rodents and Lagomorphs (Rabbits)

A wide variety of methods and systems is used to determine the presence and abundance of different species of rodents and rabbits. While the tracks of many small mammals can be learned and identified in the field, the usual method for determining the species and presence of small rodents involves some degree of trapping, either live trapping or snap trapping. Obviously, subspecies can best be determined by inhand examination of the animals, their skins, and skulls. (Certain members of the genera Dipodomys, Peromyscus, Perognathus, and Neotoma are extremely difficult to identify in the field and may require a cleaned skull, a skin, and perhaps a series of several individual animals to confirm the identifications. Juveniles are particularly difficult to identify and may require use of comparative skins and skulls.

a. Considerations in determining species occurrence and relative abundance of rodents and other small mammals.

(1) It may be necessary to snap-trap for a minimum of five nights and utilize several thousand trap nights in some areas to remove the more common rodents, or those most active in early evening, to catch the more secretive, rare, trap-shy, or late night species. By nature, some species are more active early in the night, while others are more active later.

(2) Most researchers seem to prefer a combination of snap-traps and live traps to obtain a representative sample of all species present. Researchers report varying results when only one type of trap (snap vs. live) is used for sampling. Museum specials can be purchased from Woodstream Corp., P.O. Box 327, Lititz, PA 17543. Sherman live traps are available from H. B. Sherman Traps, Aenon Creek Industrial Park, Route 4, Box 529 X-2, Tallahassee, FLA 32304. Telephone (904) 575-0424.

(3) Most experienced trappers of small rodents prefer to use some kind of bait, usually incorporating peanut butter and oatmeal (or rolled oats). Other ingredients may include blood meal, raisins, chipped beef, ground carrots, melted beef fat, and high melting point paraffin as used in imbedding tissue. Also, where the bait is to be used only in kill traps, it is helpful to mix in an ant pesticide to reduce loss of bait by ants and other insects which frequently cause a great addition of labor in rebaiting traps. (One percent rotenone is good).

(4) A few highly skilled small mammal trappers do not use any bait on/in their traps. By placing the traps in runways or other areas known or expected to be used by the animals, the trapper is capable of catching adequate samples without using bait. Some trappers contend that the use of bait will bias the catch, taking those particular individuals that are attracted to the specific bait items.

(5) Because of lack of expertise of most biologists in identifying subspecies (some of which may be endangered or threatened forms), it is recommended that contracts or other arrangements be made to send all specimens to qualified museums or universities for identification. If this is done, be sure proper measures are taken to preserve the specimens during shipment so they will be in good condition upon arrival at the institution. Obviously, this will not be necessary if qualified taxonomists are available inhouse or with cooperating agencies.

(6) Traps should be baited in late afternoon or early evening, depending on time needed and help available, and should be checked as early as possible the following morning. Many desert areas heat up rapidly and dead animals will spoil quickly in the heat. Animals in live traps may also die, which is both inhumane and unnecessary, as the temperature rises.

(7) Permanently molded live traps seem to be preferred to collapsible live traps. However, the number to be set and the distance they need to be carried will have a bearing on the type used. (Rodents are more apt to chew through aluminum live traps and gain their freedom than they are with tin traps.)

(8) Experts disagree on the number of trap nights needed for an adequate sample of small rodents. Most trappers use three trap nights, but many others prefer a minimum of five trap nights to be more sure they are taking the less common species. We suggest a minimum of 500 trap nights per habitat site sampled. (Three traps per station (2 museum specials + 1 rat trap) for 25 stations = 75 traps; 75 traps for three trap nights = 225 trap nights X 2 separate lines = 450 trap nights. Three separate lines per habitat site would be much better.

(9) Adequate samples may be taken in either spring or fall. Maximum dispersal of young occurs in the fall and some trappers feel they obtain better results on species occurrence at that time.

(10) Consult with local (or other) experts and obtain their views on best trapping methods for your area to obtain your specific objectives. This can greatly improve your success.

(11) Small rodents and other small mammals have specific microhabitat preferences, e.g., some predominantly utilize washes, certain bushes, rocky areas, or wet areas. In sampling for species occurrence and relative abundance, we must be sure to sample for the expected species in these microhabitats. While all animals move around an area within certain inherent limits, it is best to place traps within or adjacent to these preferred microhabitats. Setting traps five or six feet from the centerline of your transect to improve the chance of taking additional species is valid.

(12) Use of museum specials is recommended, in combination with rat traps. Regular mouse traps permit many animals to escape, do not last as long, and are less satisfactory for many reasons. Because of their smaller size, the rodent's skull has more chance of being destroyed and it might be needed for identification.

(13) When using live traps, consider placing a shingle on top of the trap with a rock to hold the shingle on. This seems to improve efficiency and provides shade in early morning heat. Also, wool (fleece) is highly recommended as a bedding material in live traps.

(14) Trapping is more successful on moonless nights, perhaps because of the rodents' instinctive fear of aerial or other predators.

(15) For sampling diurnal rodents, set the traps as early in the day as possible. Check them before or approximately at noon and spring them. Reset them in the cool of the afternoon (relatively speaking) and rerun the line before dark. Remove animals and spring the traps.

(16) There is considerable variability in the daily and seasonal behavior of various rodents and the times species are above ground and available for trapping. Some hibernate or estivate, while others spend parts of the year underground where they are active. Therefore, try to determine from literature or local experts when various species are expected to be most active above ground and concentrate on trapping during those periods. Trapping for species occurrence and

relative abundance during all four seasons is highly desirable to obtain a more complete picture of the total activity in an area.

(17) Small mammal populations fluctuate from season to season and year to year, depending upon weather conditions such as drought, long winters, high winds, etc. Some species may be more difficult to trap in dry years than in wet years. If poor weather conditions exist, it may be necessary to reschedule the trapping.

(18) Voucher specimens of rabbits may be taken either by shooting or by the use of Shieler traps. Censuses of rabbits may be made by walking or driving along pre-established transects and estimating the distance of the cottontail/hare from the transect line. The "effective width" of the strip along the transect, from which estimates of population are calculated, is calculated as some function of the observed distances of the animals. Some width should be used, within which the biologist feels he has observed most of the rabbits present.

b. Sampling Procedures.

(1) Linear Trap Line: A basic sampling design follows, but modifications may be made to fill specific needs.

(a) The basic sampling unit consists of a straight line of 20 to 30 trapping stations. The author recommends 25 stations with an interval of 50 feet between stations (Fig. 1). Figure 1A is a simple field form used for recording field data.

(b) Three traps are placed at each station, usually one rat trap and two museum specials. Traps should be placed roughly in a triangle at each station to cover the general area of the station, and approximately 5 to 10 feet apart. If desired, a Sherman live trap (which is large enough for rats), may be substituted for the rat trap. Trap placement may be biased toward sites where rodent sign or preferred micro-habitats are present. Use of regular mouse traps is discouraged.

(c) Install one 5-gallon pitfall (bucket, plastic container, etc.) at every fifth station, for a total of five pitfalls per trapline.

(d) For a more adequate sample, it is recommended that a minimum of two parallel traplines (set 400 feet apart) of the same type be placed within each habitat site being studied. For purposes of statistical analysis of trapping results, it is recommended that eight such traplines (i.e., four pairs of lines) be run.

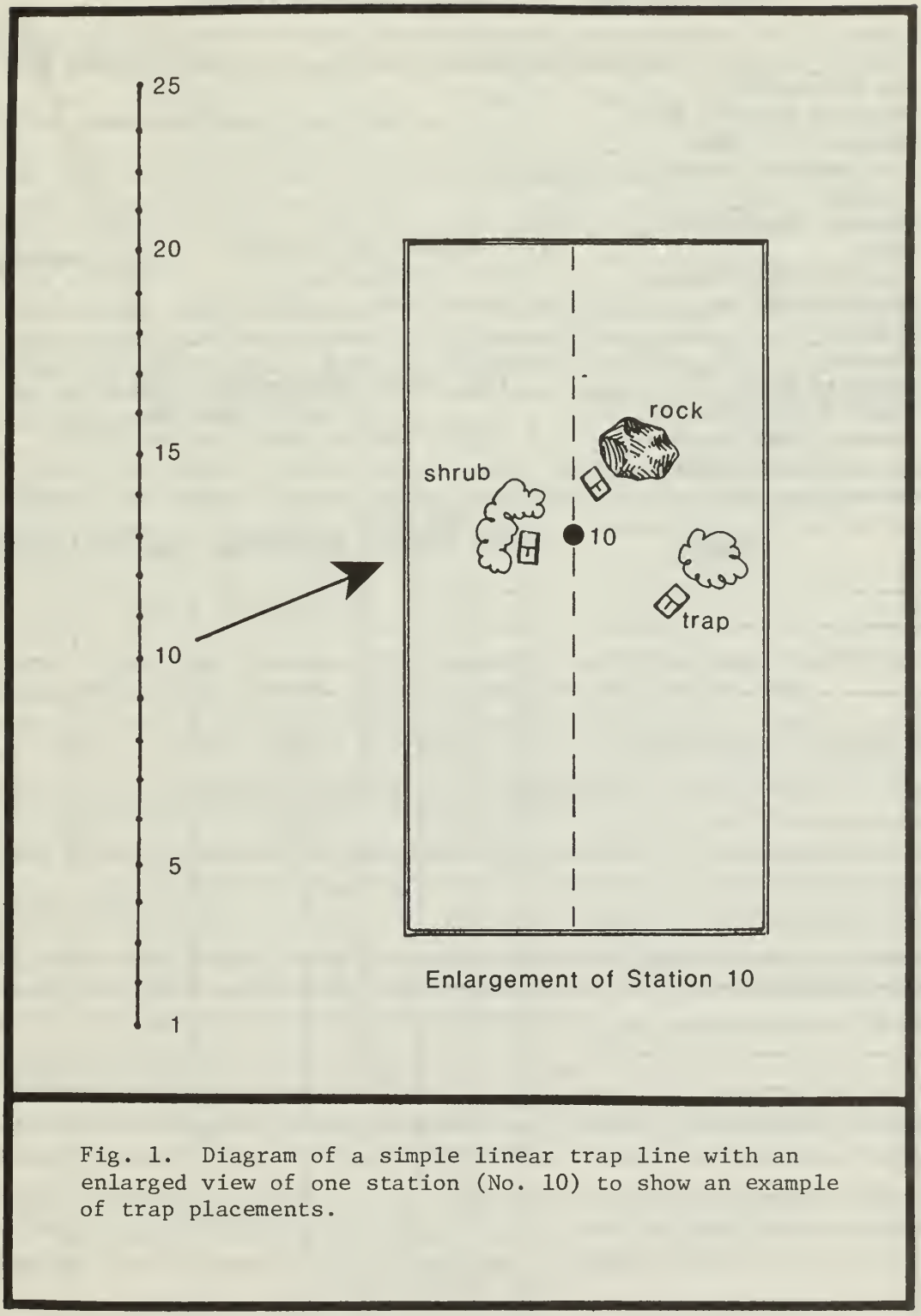


Fig. 1. Diagram of a simple linear trap line with an enlarged view of one station (No. 10) to show an example of trap placements.

Fig. 1A

FIELD DATA SHEET --- ANIMAL TRAPPING RECORD

(1) State___ ___ ___ (2) District/Resource Area___ ___ (3) Planning Unit___ ___
(4) Map Reference___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(5) Wildlife Habitat Area ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(6) Habitat Site Name ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(7) Site Writeup Number ___ ___ ___ ___ ___
(8) Location: T___ ___ ___ R___ ___ ___ S___ ___ ___ ¼___ ___ ¼___ ___
(9) General Place Name ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(10) Date ___ ___ ___ ___ ___ (11) Vegetation Structure ___ ___ ___ ___ ___ ___
(12) Physiographic Region___ ___ (13) Association___ ___ (14) No. of Traps___
(15) Trap Spacing (m)___ ___ (16) Trap Type___ ___ ___ ___ ___ ___ ___ ___ ___
(17) Trapper___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(18) Weather___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
(19) Stage of Moon___ ___ ___ ___ (20) Temp. Evening/Start (C)___ ___ ___ ___
(21) Temp. Morning/Finish (C) ___ ___ ___ ___ (22) Night No. ___ ___ ___ ___
(23) Percent Trap Success ___ ___% (24) Percent Live Trap Mortality ___ ___%
(25) No. of Traps Sprung ___ ___ ___ ___

Trap #	Species	Toe Clip				Number	Capture	Recapture
		LF	RF	LH	RH			
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

INSTRUCTIONS FOR COMPLETING FIELD DATA SHEET -- ANIMAL TRAPPING RECORD

Items 1 and 3 Enter standard two-digit codes from BLM Manual Section 1265

Item 2 Enter required three digit code.

Item 4 Map Reference - Name and scale of USGS Quadrangle.

Item 5 Wildlife Habitat Area - Official name and/or number assigned by District Manager.

Item 6 Habitat Site Name - Assign site name code consisting of abbreviation for the dominant and subdominant plant species (six spaces each), and three-letter land form code. Refer to BLM Manual Section 4411 for plant sysmbols and BLM Manual Section 6602 for land form codes. See official range survey for the plant species needed.

Item 7 Site Writeup Number - Enter first letter of last name of recorder and three numbers indicating, consecutively, the number of the habitat site in the planning unit. See official range survey. Leave blank if unavailable, do not create your own number.

Items 8, 9 and 14 Enter as indicated.

Item 10 Date - Enter date inventory is conducted; record as year, month, day. Zeros must precede months and days numbered one through nine.

Items 11, 12 and 13 Enter standard two-digit codes from BLM Manual Section 6602.

Item 15 Trap Spacing - Approximate distance in meters.

Item 16 Trap Type - Live, kill, steel, box, pitfall, etc.

Item 17 Enter your name.

Item 18 Weather - Brief indication of conditions prevailing during the trap night (e.g. overcast, rain, snow, high winds, etc. If a foot transect, show prevailing conditions during the transect.)

Item 19 Stage of Moon - Full, half, quarter, or new.

Items 20 and 21 For trapping cross out start and finish. For reptitle or amphibian transects cross out evening and morning.

Item 22 Night No. - First night, second, third, etc., of a particular trapline set.

Item 23 Percent Trap Success - $\frac{\text{No. of captures (item 26)}}{\text{No. of active traps}} \times 100.$

Active traps = No. set (Item 14) less No. sprung but not having an animal (Item 25).

Item 24 Percent live trap mortality - $\frac{\text{No. dead}}{\text{No. caught}} \times 100.$

Item 25 No. of traps Sprung - Enter number of traps sprung but not having an animal.

(e) The traplines should be run for a minimum of three consecutive nights. (However, the author recommends a minimum of four consecutive nights.) Trapping for five consecutive nights, as stated in item 1(a), will sometimes provide additional species, after the more common species have been removed.

(f) The terminal ends of the trapline should be marked with stakes, flagging, or other visible material. Permanent stakes would be desirable for future reference; the locations of these markers should be marked on maps so they may be relocated at a later date. In forested areas, you may wish to run a heavy cord (1/8 in.) through the habitat and attach tags at the appropriate places to facilitate finding the traps. Or, strips of flagging material may be tied to branches for identifying each trapping station.

(g) Trapping results may be better in spring or in fall, depending on locality. Check with university or museum experts for recommendations on best seasons. In some areas of the West, the peak period of juvenile dispersement occurs in the fall (Thomson, 1980).

(h) At least one vegetation transect (to include canopy coverage) should be run in each sampled habitat site. Provide a thorough description of the vegetation or site where the trapline has been placed. Include such items as abundance of trees, shrubs, or grasses; seral stage of the plant community; disturbance by livestock, fire, man, etc.; presence of logs, debris, rocky cover, etc,; and size of trees and species in forest situations. Include a brief description of topography, e.g., elevations, slope, relation to drainage system, nature of the soil, aspect, etc. For future reference a photograph of the habitat site would be helpful.

(i) Make a notation in your field notes concerning the weather condition at the time the traps were in operation.

(j) Tabulate trapping data by species per 100 trap nights by habitat site and by date.

(k) Data reliability may be increased by increasing the number of parallel traplines in each habitat site and by sampling additional SWA's within any given SHS.

(l) A variation of mixed snap and live trapping has been proposed by Laudenslayer and Berry (1977). They suggest setting out snap-traps in a ratio of 3 museum specials to 1 rat trap in 3 parallel lines with <u>one</u> trap per station. The lines are spaced 15 m apart; within lines, traps are 6 to 7 m apart.

Each line consists of 167 traps, with a total of 501 traps. Two lines of 100 Sherman live traps each are placed in an adjacent area, with spacing the same as stated above. Grids are operated for three consecutive nights. All traps are to be checked and rebaited four times a day at 2200-2400 hours, 0500-0700 hours, 1000-1200 hours, and 1700-1900 hours. Different animals have different activity patterns, so checking and rebaiting the traps periodically will ensure the collectors of maximizing their catch.

A population estimate may be made using this technique by plotting the number of animals captured, as shown in Figure 2. A regression line is drawn through the points and the population size is estimated from the intersection of the regression line and the x axis (Chapman, 1954; Moran, 1951). Laudenslayer and Berry (1977) point out that this technique often results in inaccurate results, especially if the numbers trapped per night do not decrease through the trapping period, which is quite possible. (In this case, trapping would need to be continued until a definite downward trend in catch per night were observed.)

(2) Trapping Grid: For small mammal population estimates, determinations of average ranges, or greater statistical reliability, a trapping grid may be set up.

(a) The small mammal live trap grid is a system for live trapping many of the small mammals in a prescribed area, marking and releasing them, and then running a snap-trap transect through the grid for making a population estimate, using a simple Lincoln Index. Both the live trapping results and the snap-trapping results will provide considerable information on distances traveled by individuals and by species.

(b) A hand compass is usually used for laying out the grid and requires two people. All points are staked for placing live traps.

(c) A Sherman live trap is placed at each of the 99 stations.

(d) These live trap stations are 50 feet apart in each direction and should be laid out approximately as shown in Figure 3.

(e) After approximately five nights of live trapping and marking of captured animals, a snap-trap transect is run through the center of the grid to make a population estimate, using a simple Lincoln Index procedure. The snap-trap transect is extended 250 feet on each side of the grid to be able to capture marked animals that may travel at least that far from the outer live trap stations where they were captured and marked. Snap-trap stations are 50 feet apart.

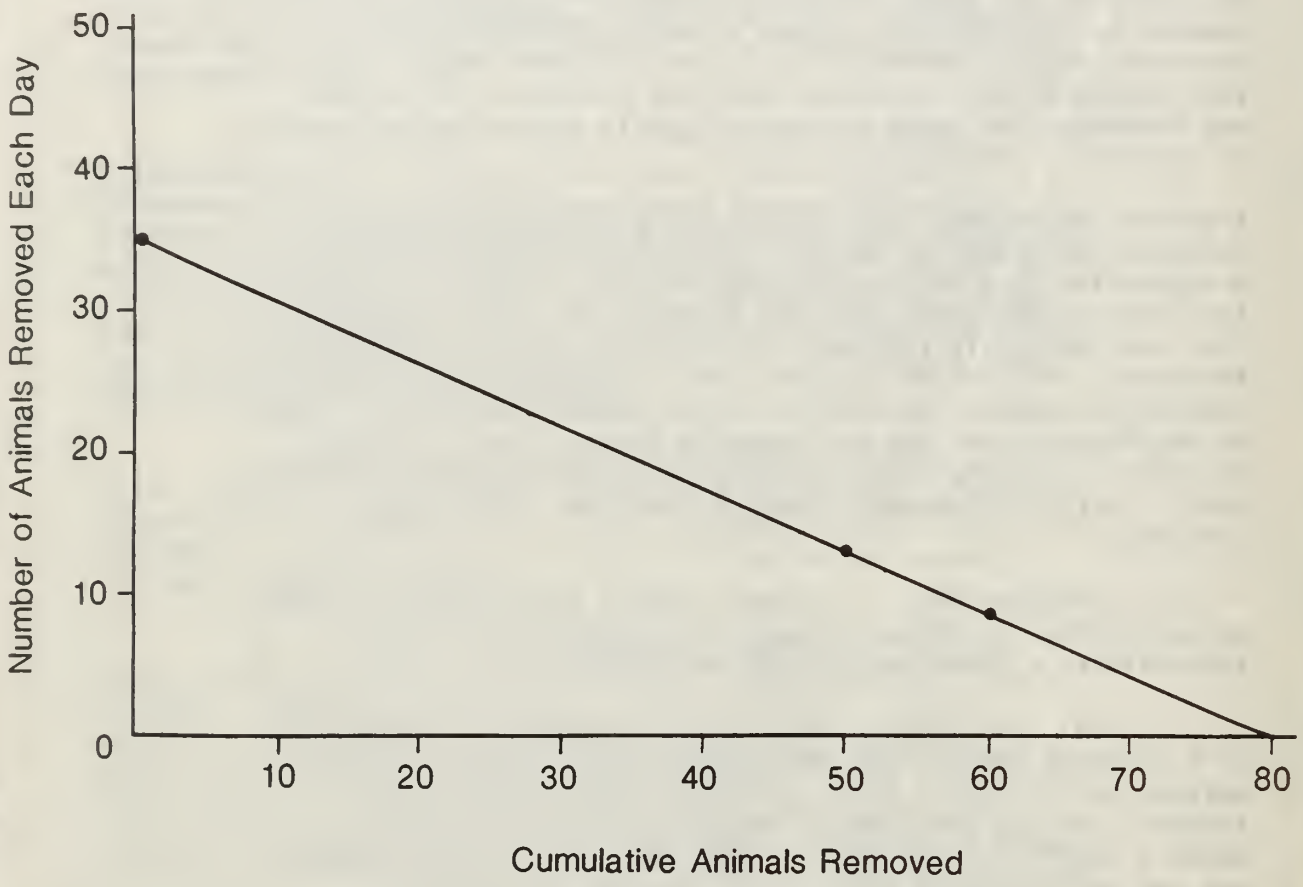


Fig. 2. Method for estimating animals in a population by plotting animals captured each day against total previous cumulative catch. In this example, 35 animals were captured the 1st day, 15 the 2nd day, and 10 the 3rd day. In this case, we would estimate the total population to be between 70 and 80 animals, or approximately 80 animals.

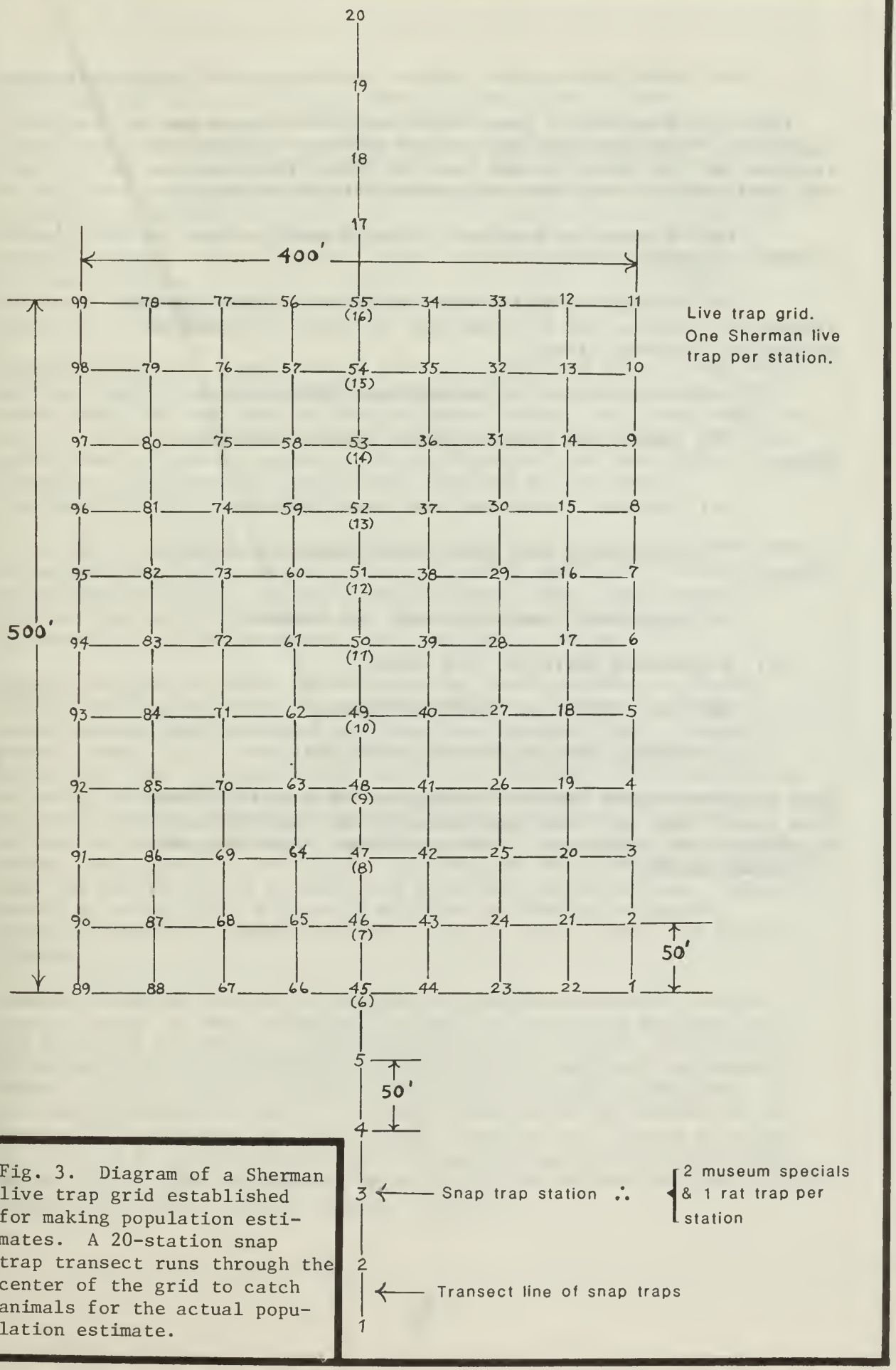


Fig. 3. Diagram of a Sherman live trap grid established for making population estimates. A 20-station snap trap transect runs through the center of the grid to catch animals for the actual population estimate.

(3) Bait Mixtures: A wide variety of bait mixtures may be successful. Biologists may want to try different mixtures to find the one that seems to work best for them. Following are some mixtures that have been very successful for snap-traps:

(a) A ground up mixture of chipped beef, carrots, raisins, and peanut butter.

(b) Mixture of melted beef fat, peanut butter, ground raisins and oatmeal, and a little high melting-point paraffin as used in imbedding tissue.

(c) Plain mixture of oatmeal and peanut butter.

(d) Mixture of oatmeal, peanut butter, and bacon grease.

(e) Mixture of bird seed and peanut butter.

(f) Mixture of bird seed, peanut butter, and bacon grease.

(g) Mixture of jam, bird seed, and oatmeal.

(4) Recommended baits for live traps:

(a) Hen scratch and sunflower seeds.

(b) Rolled oats and/or wild bird seed.

Some trappers mix the ingredients together with a little water in a plastic bag, and then keep squeezing the bag until all ingredients are well mixed. Addition of some blood meal helps to attract shrews.

Arboreal Rodents. Some species of rodents, such as squirrels, wood rats, and some mice, are largely arboreal (they live in trees). Consequently, they may not be taken in the usual traplines. To collect these species, place live or snap-traps on platforms in trees or fasten them to limbs. Traps may also be placed on the ground around the base of the trees where some evidence of the animals is found. Signs, such as caches, clippings, and calls, are useful in species identification. Animals observed during the daytime may be shot if the specimens are needed. Special Conibear traps, which catch the animals around the neck or chest, killing them almost instantly (see Collier, 1957), may be obtained, which are useful for taking mammals ranging in size from squirrels to beaver.

Fossorial Rodents. Some rodents, such as gophers and moles, live almost entirely underground (fossorial). Gophers may be captured using gopher traps, which are available at many hardware stores. The traps should be set in all gopher tunnels leading from one or more mounds and should be staked down to prevent gophers from pulling them into their burrow complexes. Occasionally, gophers are captured in snap-traps (Laudenslayer and Berry, 1977).

Moles may be captured using gopher or special mole traps. A gopher trap set upside down in the animal's burrow is often useful for obtaining moles (Ingles, 1965). Special commercial mole traps consisting of a boxlike housing which opens at the ends and has an impaling device actuated by a trigger mechanism, are also useful (Giles, 1969).

Shrews. Shrews and other insectivores are rarely captured utilizing traditional trapping methods for small mammals. Because they are insectivorous, they are often not readily attracted to bait composed of peanut butter and/or oatmeal. One of the most effective methods for collecting them is by the use of pitfall or can traps (which may also be effective in catching amphibians, reptiles, and other small mammals). For best results, the cans (or buckets) should hold more than one gallon, be square, and have a round aperture in the center, which helps reduce the possibility of escape. The cans are buried in the ground so that the top of the can or bucket is flush with the substrate. The cans should be covered with a board of masonite or plywood, or similar material, which is supported by four rocks or other objects, as shown in Figure 4.

Because shrews move about very rapidly or perhaps because they smell meat (or smell or hear other small animals on which they may feed) in the bottom of the pit trap, they frequently drop into the pit and cannot climb back out. If the pitfalls are baited with sardines, earthworms, rodent brains or liver, or other meat, more shrews may be obtained. If you cannot examine the traps on a daily basis, 10 cm of formalin or AFA (Giles, 1969), covered by a thin layer of mineral oil, should be placed in each can to retard decomposition of the specimens (Laudenslayer and Berry, 1977). This will also help to prevent the shrews from destroying and/or eating other trapped animals in the pit.

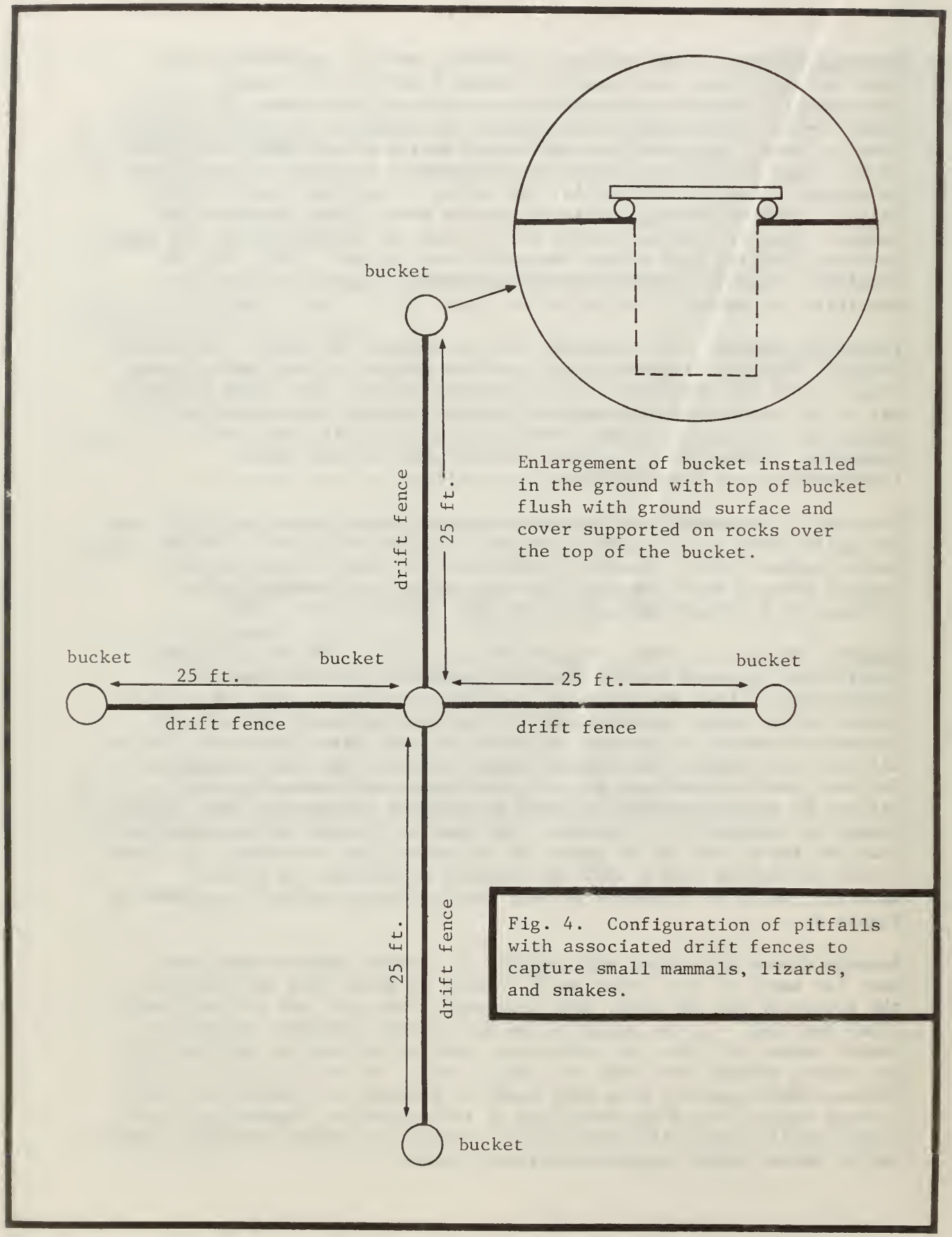


Fig. 4. Configuration of pitfalls with associated drift fences to capture small mammals, lizards, and snakes.

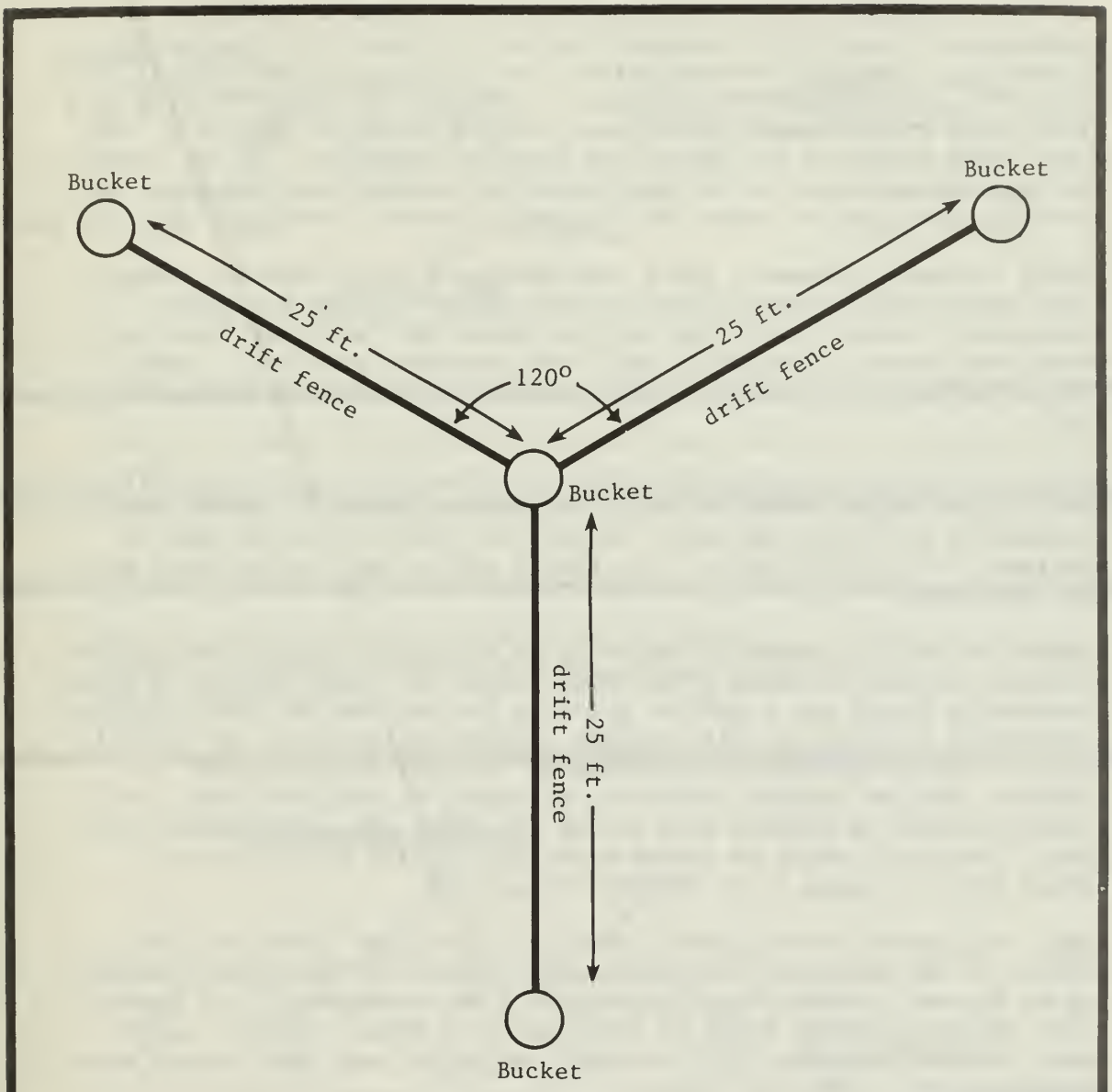


Fig. 4A. A trapping configuration for capturing small mammals and reptiles using three arms instead of four (See Fig. 4.). This design has proved very effective in Arizona (Bruce Jones, pers. commun.).

For line transects, it is recommended that pit traps be installed at approximately every fifth trapping station, or about five pits for every 25 stations. Another recommendation is to place five cans, buckets, etc., in a cross-shaped configuration, with each can site connected by a drift fence of wire mesh, approximately 0.3 m in height (Fig. 4). The drift fence should be set about 3 cm into the substrate. If the animals are believed to occur in very low densities, sample plots should be expanded in size and/or number and the area of survey increased. Also see Fig. 4A.

Shrews are more frequently found near permanent water sources. Therefore, the biologist should seek out such areas to check for their occurrence. Shrew sign is not easy to detect but, with practice, the worker can learn to recognize their runs, burrows, and nests. Leaf litter, matted grass, and moist ground are good habitat signs to look for.

Care should be taken in handling live shrews as some species secrete a toxin in the saliva which can make a bite quite painful. Gloves are recommended when handling them. Unless you intend to retain them as specimens for identification, they should not be kept in captivity more than two hours.

Another method for capturing shrews is to dig small trenches between the pitfalls, instead of using drift fences (Fig. 5). Good success is often achieved by laying out a grid of pitfalls (coffee cans or other suitable containers) adjacent to small streams or other moist areas, as shown in Fig. 6. Bait is placed in the bottom of the cans and along the trenches, and the trenches should be moistened so they are damp. The trapline should be checked once during the night and again before sunrise. The traps should be closed with plastic lids during the day unless they are going to be visited frequently.

Bats. Biologists should always take care not to get bitten by bats because of the potential for contracting rabies. If extensive collecting is planned, rabies inoculations should be considered. Bats normally roost and are commonly found in such places as mines, tunnels, caves, banks or cliff crevices, old buildings and barns, and other places where they may crawl or squeeze into.

If roost sites or nurseries are located, the bats may be identified and direct counts made at the site. One of the most practical ways to capture bats for identification is to place mist nets over ponds where bats forage and drink, across corridors of observed flight paths, across roost caves and at cattle water tanks, or across small springs, ponds, and detention dams. Small pools in desert areas where water is scarce are good places to find bats, partly because of the water and partly because of the associated insects. Setting mist nets perpendicular to low cliff faces is also a good method for taking bats, as they frequently roost in such places. Nets should be erected about sunset and monitored constantly. Bats should be removed as quickly as possible after capture so that they do not become tangled in the net.

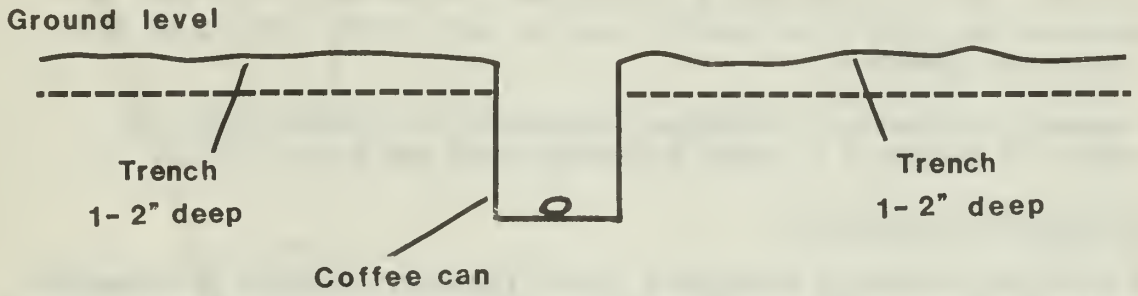
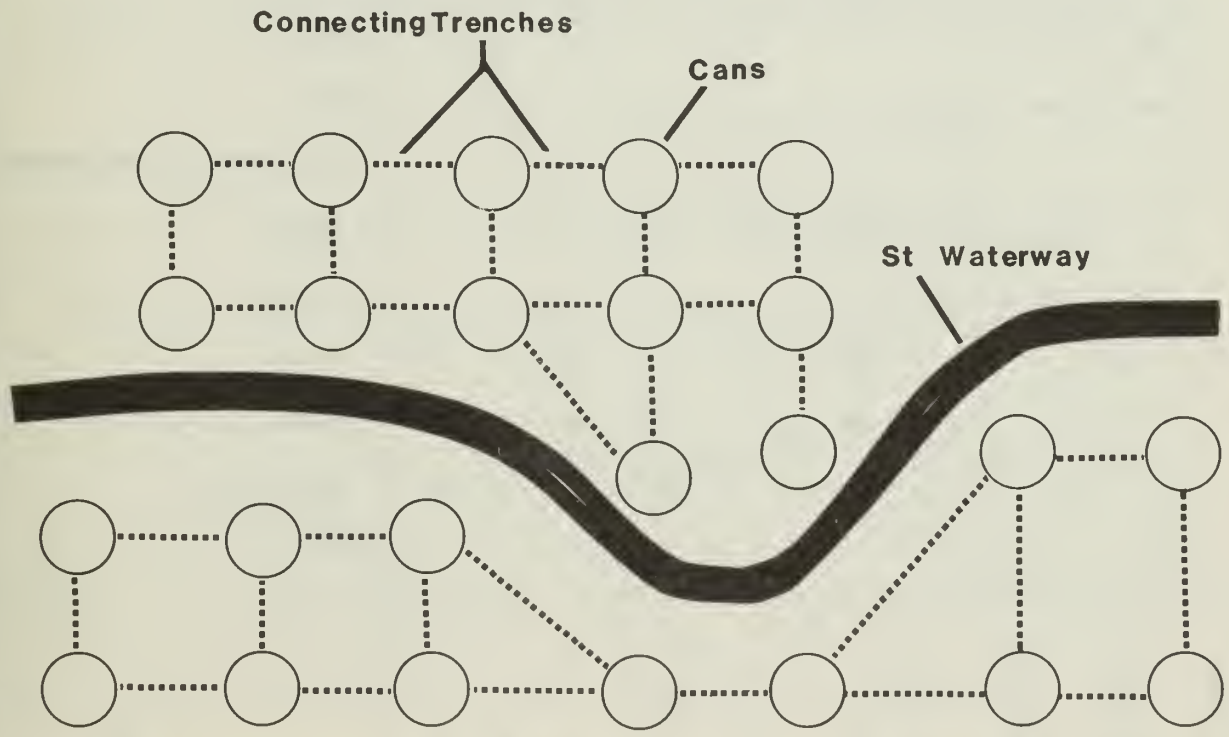


Fig. 5. Diagram of pitfall and associated trench for catching shrews.

Fig. 6. Grid pattern of pitfalls and trenches for collecting shrews along a waterway. Trenches are interconnected with pitfalls to guide shrews into the pits.



Bats may also be taken with a .22-caliber firearm using dust shot or a shotgun using size 9 (or smaller) shot in areas where setting up mist nets is not feasible.

A summary of inventory techniques applicable to different kinds of mammals is presented in Table 3 (Laudenslayer and Berry, 1977).

Supplemental Information

In addition to species occurrence and/or relative abundance information obtained by trapping, animal signs, etc., considerable additional information on species occurrence may be obtained through the collection and examination of pellets disgorged by birds of prey, especially owls. Most owls have relatively small home ranges, but it is not unusual to find the remains of rodent species in their castings that are different species from those obtained by trapping. This source of information should not be overlooked.

Also, whenever pitfall traps are installed, all animals that fall or crawl into them should be recorded. For example, a great variety of insects, including desert beetles, scorpions, etc., will fall into the traps. Many of these animals are nocturnal species that are seldom seen in daylight. They are all part of the total animal biomass for that particular habitat site and should be evaluated for their roles in the ecosystems they occupy.

Table 3. Summary of Inventory Techniques for Various Groups of Mammals.*

Mammal type	Inventory Techniques																			
	Traps	Pitfalls	Snap	Live	Steel	Gopher	Herd (large ungulates)	Scats	Tracks	Dens	Transect-observation	Sightings (casual)	Shooting	Mist Nets	Predator Calls	Aerial search	Drive count	Drugs	Snares	
Insectivores		X	X																	
Chiropterans												X	X	X						
Lagomorphs			X								X	X	X				X			
Rodents (Terrestrial)		X	X	X								X	X							
Rodents (Arboreal)			X	X								X	X							
Rodents (Fossorial)			X	X		X				X										
Rodents-Carnivore (Aquatic)					X			X	X	X	X	X								
Small Carnivores/ Omnivores					X			X	X	X	X	X								
Large Carnivores/ Omnivores					X			X	X		X	X						X	X	
Large Herbivores							X	X	X		X	X			X	X	X	X	X	

*Laudenslayer and Berry, 1977).

REPTILE INVENTORIES

Reptile inventories primarily involve searches for snakes, lizards, and tortoises. The wide variety of species and respective variety of habitats occupied by these animals demand that searches for them be spread over all kinds of habitats--from marshes to true desert and across many soil and vegetation types.

Recognize that some species of reptiles occur only in certain habitat sites (types) or only in areas having certain soil textures. Examples include the Mojave fringe-toed sand lizard (Uma scoparia) found in windblown or eolian sands; the chuckwalla (Sauromalus obesus) found only in areas displaying certain kinds, size and spacing of rocks, and having specific soil surface characteristics; and the desert night lizard (Xantusia vigilis), which prefers habitats containing Joshua trees. Other species favor certain kinds of habitat but can be found elsewhere, such as the desert iguana (Dipsosaurus dorsalis) and the shovel-nosed snake (Chionactis occipitalis), which prefers windblown sands but is sometimes found elsewhere. Many other species are similarly habitat-specific.

For the purpose of this Technical Note, reptiles have been divided into three groups: lizards, snakes, and turtles. Then they are further subdivided according to habitat type occupied.

1. Lizards (Saurians). Techniques for capturing lizards will depend on habitats occupied and behavior of the species involved. There are no aquatic lizards in the U.S. In the western U.S. the two basic types of lizards are:

a. Fossorial Lizards. These are species which spend most of their lives underground, e.g., Anniella spp.

b. Terrestrial Lizards. These species spend most of their lives above ground, except genus Anniella.

2. Snakes (Serpents). Snakes are classified as either aquatic or terrestrial, and further classified as being either diurnal or nocturnal in habit.

a. Aquatic Snakes. In the western United States, Thamnaphis and Nerodia (portion of genus Natrix, according to Rossman and Eberle [1977]) may be considered to be generally aquatic, although Ficimia, Heterodon, and Sistrusus spend much time in moist, if not true aquatic, habitats. However, it should be pointed out that all snakes are excellent swimmers.

b. Terrestrial Snakes. Most of the snakes in the western United States are terrestrial species, although in varying degrees. Species that are largely arboreal (live in trees) are included in genus Oxybelis in Arizona and genus Opheodrys in Texas and Colorado. Genera that include fossorial (living underground) species include Leptotyphlops, Sonora, Chionactis, Chilomoniscus, Tropidoclonion, and Tantilla. Inventory or collecting methods are aimed at collecting the snakes during the period they are above ground.

As with other animal group inventories, appropriate reviews of available literature and field guides should be made; museums should be visited or contacted for species occurrence in the area of interest; and authorities should be visited, including university personnel, other Federal agencies, State wildlife agencies, or local experts. Many of the larger museums have collections from many of the western states, possibly from within the area of concern.

3. Turtles (Chelonians). As with other reptiles, techniques for capturing turtles depends on habitat and habits. Turtles are herein divided into aquatic and terrestrial species. Most turtles can be taken during the day, notably in the morning hours.

a. Aquatic Turtles. In the western United States, the genera Chelydra, Kinosternon, Clemmys, Chrysemys, Pseudemys and Trionyx, are aquatic types, occupying a variety of habitats ranging from lakes and rivers to small temporary ponds.

b. Terrestrial Turtles. Only two genera, Terrapene and Gopherus, are considered to be terrestrial in the western states. The former is primarily a prairie or woodland dweller while the latter is a desert resident (desert tortoise.)

INVENTORY TECHNIQUES

Techniques for collecting and identifying lizards, snakes, and turtles include the following:

1. Road Riding. Road riding may be done either during the day or at night, but success is usually better towards evening or during the night because many species are largely nocturnal. Many species are completely inactive during the daytime since they cannot stand the high temperatures. The road riding method is highly effective in the arid Southwest, especially during the spring (April, May, and June) and on warm, moonless nights. In Arizona and New Mexico the months of July, August, and September usually produce results at night after summer thunderstorms. The driver should drive slowly enough to observe small snakes and lizards on the roadway. Road riding may also be effective on warm spring mornings when reptiles often move to the edges of the roads to sun themselves. Many species will retreat quickly when a vehicle stops. One of the following methods may be used to collect the specimens:

a. Shooting. Shooting is one of the simplest and most effective methods of collecting most turtles, lizards, and snakes. However, firearm discharge may not be permitted in the area and the biologist may also not wish to kill the animals. However, if the specimen is needed for in-hand identification or for a voucher specimen, etc., it may need to be killed. A .22-caliber pistol loaded with bird shot is very effective and minimal damage is usually done to the specimen. Where shooting is not allowed, a slingshot may be effective. Be aware that aquatic species shot while swimming usually sink.

b. Noosing. Noosing is an effective method for collecting lizards. A slender three- to five-foot pole, such as an old fishing pole, works very well. Tie a small (less than 6-in.) section of dental floss or monofilament fishing line (5-lb. test, or lighter) to the tip end of the pole. Make the line into a slip knot; the loop should be only large enough to slip easily over the lizard's head. Lower the loop slowly over the lizard's neck and then pull backward and upward when it is around the neck. Do not jerk too hard or the specimen may suffer injury. Different procedures are used for noosing whiptails (Cnemidophorus). Because of their narrow heads and short necks, they can easily slip out of the loop if lifted off the ground. Therefore, when the loop has been placed around the neck, it should be pulled slowly backward and downward until tight, and then the collector should reach down and pick the lizard up. It should not be lifted off the ground with the noose at any time.

2. Turning over Rocks, Boards, and Other Debris. This is an effective method for finding some of the more secretive species that do not move about very much, such as skinks (Eumeces spp.), night lizards (Xantusia sp.), rubber boas (Charina spp.), ringneck snakes (Diadophis spp.), and sharp-tailed snakes (Contia spp.). The basic procedure is to search under old boards, rocks, logs, pieces of metal, or any other loose material or debris lying on the ground that may provide cover for small reptiles. Each species will have their specific preferences for cover. Rubber boas appear to prefer old bark flaking off logs, while granite night lizards can only be found under exfoliating granite pieces. By nature, most reptiles prefer much drier situations than amphibians, so looking under moist or moldy habitats will be much more productive for amphibians than for reptiles. However, the biologist will usually be looking for all wildlife forms within a particular area, so everything found will be noted. During the search process, try not to disturb the habitat any more than necessary so that it will be suitable for continued use by the multitude of small creatures that preiodically may use it. Replace rocks, boards, etc. in as near their original positions as possible.

3. Installing Pitfall or Can Traps. Both amphibians and reptiles are sampled most effectively with pitfall cans and funnel traps with drift fences (Fig. 4). Containers used in pitfall traps can be coffee

cans, glass jars, metal cylinders, plastic buckets, etc. but should be sufficiently deep to prevent animals from escaping. Five-gallon cans with a lip (rectangular in shape with a round opening) are much more effective in retaining lizards and snakes. Gila monsters require two (2) five-gallon cans, one on top of the other.

The pitfalls are installed by digging a pit large enough for the container and installing it so that the lip is just at, or slightly below, ground level. Excess material should be scattered around the area so as not to be an obstruction. The pitfalls may be installed as part of a linear trap-line for small mammals or in a separate array designed specifically to catch snakes or lizards. When installed as part of a small mammal trap-line, the pitfalls should be placed at approximately every fifth station. A simple pattern for a lizard-snake trapping array consists of four 25-ft. lengths of 8- to 12- in. valley tin arranged in a cross-shaped pattern. The drift fences are buried 2 to 4 in. below the surface level and held erect with surveyor's stakes, spikes, etc. At each end of the array, preferably a five-gallon container is sunk into the ground to just below ground level. A fifth container may be placed at the center of the cross, if desired. (With drift fences all running to the center of the cross, this central pitfall will probably collect considerably more animals than the outlying pitfalls. It should be checked at least once every day). Covers of masonite, plywood, or some similar material should be provided above the pitfalls to provide shade to the trapped animals. Otherwise, some of the animals may die from overheating. Such shade, low to the ground, also induces some animals to crawl under, thus increasing chances for capture. Some researchers recommend that the pitfall traps be positioned with lids attached for approximately five days before the trapline is activated to get the animals accustomed to the traps (Dr. Steven Cross, Southern Oregon State University, personal commun. 1980).

To insure collecting larger snakes which could crawl out of the cans or buckets, some workers install screen wire funnel traps along the drift fences flush against the ground and fence. The funnel traps are made of 30-in. window screening rolled into a cylinder 8 in. in diameter and fitted with screen funnels on either end. This keeps most snakes from finding their way back out of the funnels.

The general concept for this type of pitfall trap is that as small ground-dwelling animals meet the drift fence, they tend to follow along it until they fall into one of the pitfall cans. Some biologists tie a barbless artificial trout fly, insect, or artificial bait above the opening of the trap. As the animal reaches for the bait, it falls into the trap. Use of valley tin is most effective for a drift fence, but other natural materials may be used, such as rows of rocks, boards, hardware cloth, natural barriers, etc.

A different type of trap is described by Rogers (1939) who developed a box trap (10" x 10" x 32") with cardboard doors positioned on the top. The trap is buried flush with the ground. When a lizard crawls across the top of the box, its weight causes the door to drop and the lizard falls into the trap.

Fitch (1951) described a simplified type of funnel trap for reptiles as being very effective for catching squamatids as follows:

> The funnel trap consists of a piece of hardware cloth 1/4 inch or 1/8 inch mesh rolled into a cylinder and held in shape by having the edges turned back and pounded together. An entrance funnel of the same material is fitted firmly into each end. First, each end of the cylinder is turned inward at right angles, for half an inch or so, forming a skirt. The elasticity of the hardware cloth tends to hold the funnel in place when it has been forced into the cylinder as far as it will go. Shingle nails woven through the meshes of the funnel and the end of the cylinder to maintain firm contact between them provided reinforcement which was found to be especially desirable in traps liable to be disturbed by predators. A trapped animal can be removed easily by pulling the funnel from one end of the trap and shaking the animal into a cloth bag.

4. Pitfall Traps for Aquatic Turtles. Aquatic turtles may be captured by constructing simple traps utilizing the pitfall principle. A ring of chicken-wire fencing approximately 10 to 20 ft in diameter can be placed in aquatic areas frequented by turtles. The top of the wire should be 2 to 3 in. above the water level. A log or plank board about 1 ft wide should gently slope over the fence with the end outside of the ring immersed in water and the other end in the air over the inside of the ring. Turtles will generally crawl up the log or plank to bask and will fall into the water when disturbed or when temperatures become too high. The turtles can be easily removed from the trap by dip-netting.

5. Sounding Techniques for Terrestrial Turtles. Terrestrial turtles which are burrowed may be located by simple sounding techniques. This is done by trapping loose soil deposits or other likely burrowing areas with the round end of a broom handle in areas frequented by turtles and is described by Carpenter (1955). The tapping produces distinctive sounds when a turtle is located and some practice is required before the collector becomes proficient. When traps are not used, morning and night observations are recommended for each season. Amphibian and reptile faunas differ qualitatively and quantitatively during these periods.

6. Snap Traps. Snap traps will sometimes catch lizards and snakes when they are placed along well-traveled routes across washes, etc., or if a live insect is tied to the treadle of the trap. However, tying insects onto trap treadles is time consuming and probably not worth the time expended.

7. Methods for Surveying/Censusing Desert Tortoises. Basic methods for determining the presence and relative or absolute abundance of tortoises in an area include line and belt transects and some type of plot or quadrat. The method used depends largely on whether the biologist needs information only on presence and general distribution of the animals within an area, or whether more specific information is needed on population numbers and trends and habitat characteristics that are influencing their populations.

Anderson et al. (1976) used surveys along line transects to census tortoise populations. However, many researchers recognize that areas may be sampled rapidly using line transects but feel that they are primarily useful for indicating presence and/or relative abundance of tortoises. Berry and Nicholson in California (1981 manuscript in preparation) used strip transects and permanent study plots to determine the current distribution, relative and absolute densities, and population conditions. Their detailed manuscript presents the most up-to-date information on the present status of the desert tortoise in California and changes in that population during the past 70 years. Methods they used were generally as follows:

Permanent study plots were established to gather data on absolute densities, mortality rates, population age composition, and sex ratios. Data on current population condition were assessed at each permanent study plot through evaluation of density, mortality rates, size class structure, and sex ratios. Data from study plots were then correlated with transect data to prepare desert-wide estimates of population density, distribution, and conditon.

The strip transect method was used to sample distribution and densities throughout the California deserts. Transects were 2413 meters long by 9 meters wide (1.5 miles by 10 yards) and were usually walked in an equilateral triangle, 804 meters to a side. A few transects varied in length and width because no standardized method had been established early in the study period. Transect shapes were occasionally modified into different polygons in order to fit the terrain, to sample within a single habitat type, or to fit within a surveyed secton. Transect length was estimated by counting paces.

The locations of the transects were determined by their distances from previous transects; most were placed three to six miles apart. Thus, the sites were not randomly located, and they were chosen without regard to habitat type. This spacing resulted in a fairly even distribution of transects throughout the desert except where there were no roads to provide access. Transects were generally located greater than 1600 meters from a paved or well-used nonpaved road in order to avoid the influence of traffic upon adjacent tortoise populations (Nicholson, manuscript in preparation). Most transects were walked within 1000 meters of lightly used dirt roads. Transects were located in foothills, low hills, steep bajadas, and in arroyos or gullies; however, the majority were walked in valleys and on more gently sloping bajadas because these habitats were

more prevalent and found to be more suitable for viable tortoise populations. Steep and rocky mountain slopes were not surveyed. Transect sites were selected in areas typical of the surrounding two to three miles; sites with obviously heavy impacts from human-related uses (ORV pits, livestock watering areas, etc.) were avoided.

All data were recorded on a special form: the California Desert Project Standard Unit Record for Desert Tortoise Survey. Data recorded on the form included date; site description and location; number, size, location, and condition of live tortoises, shells, and tracks. A photograph (35-mm slide) was taken of each site, and a print made from each slide was attached to the corresponding completed form.

Permanent study plots were also established. The study sites were chosen in areas characteristic of large expanses of desert, in homogeneous habitats, in relatively undisturbed (insofar as possible) sites, where the goal was to find as many tortoises as possible. All tortoises located were marked in a standard fashion. The study plots were generally one square mile in size and were traversed systematically, back and forth, until no new (unmarked) tortoises were found. After initial capture, tortoises were disturbed only occasionally for measuring and weighing. Additional collected data included time of day and period of observation, behavioral activities, location and orientation, daily movements, construction and use of burrows, times of emergence and retreat, associations with other tortoises and other species, and weather conditions. A complete site description was prepared for each sampled site.

With some modifications, the above-described procedures are being used in Arizona, Nevada, and Utah. Dr. Kristin Berry (California Desert BLM District, Pers. Comm.) stated that these procedures work very well in the California Desert and parts of Nevada. However, Arizona habitats are somewhat different and Dr. Berry emphasized that calibration will be necessary in each new habitat type in which the method is used. The 1978 and 1979 Proceedings of the Desert Tortoise Council describe modifications of these procedures for use of the technique in Arizona. The author recommends that the Berry and Nicholson method of strip transects and permanent plots (with modifications made, where needed) be used in order to standardize Bureau procedures as much as possible.

Tortoises may be marked in various ways for later identification. The method employed by Bury and Luckenback (1977) is illustrated in Fig. 7. Tortoises often rest at the mouths of their burrows or in pallets, where they may not be visible beyond five meters. Young tortoises are easily overlooked unless shrubs and low vegetation are carefully examined at close range. Tortoises in burrows will be missed unless the interior of the burrow is illuminated.

NOTE: Water supply is critical for most desert animals, including tortoises. Disturbed tortoises frequently discharge their stored water when picked up, but gentle handling and pressing the tail firmly against the cloaca will often prevent urination while the tortoise is being measured or examined. ALWAYS handle them carefully.

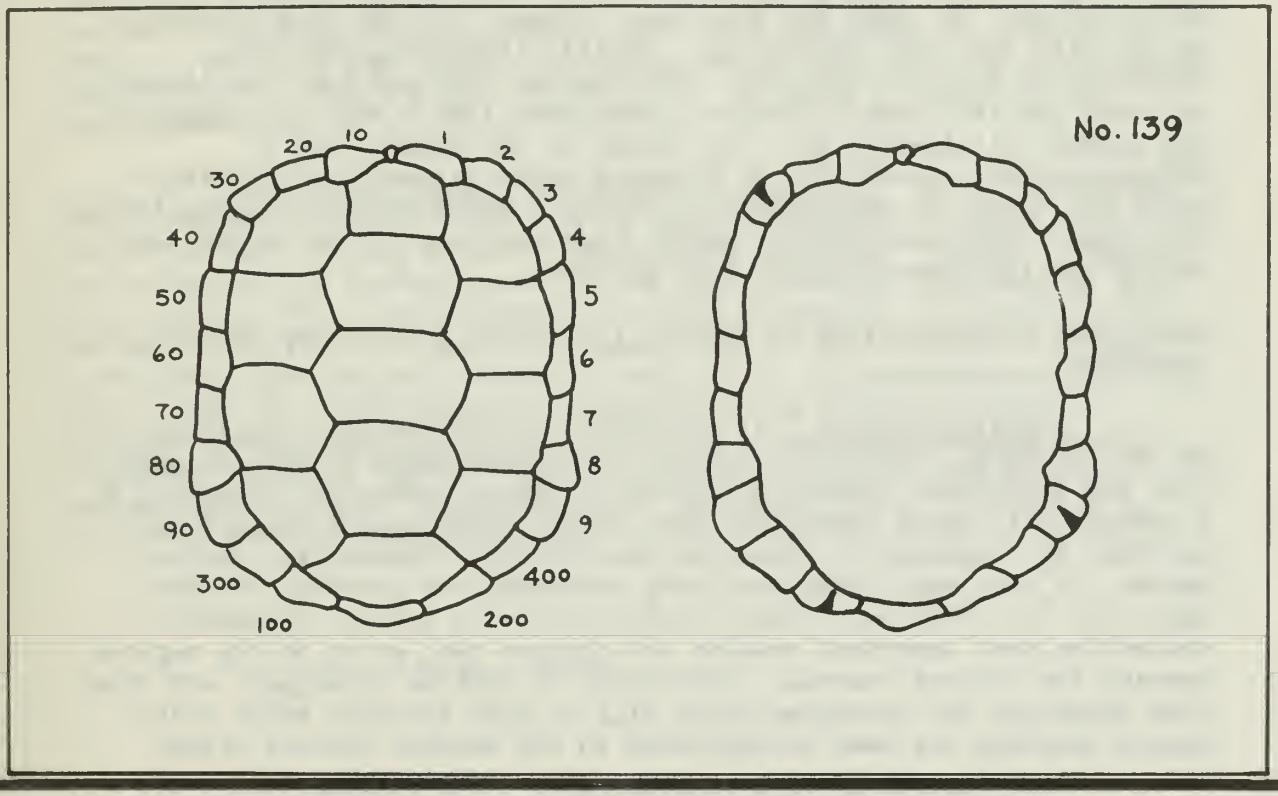


Fig. 7. Method of marking tortoise scutes employed by Bury and Luckenback (1977).

8. Suggested Method for Censusing of Lizards. A simple method for censusing of lizards was proposed by Karen Boyer and Ed Wessman of the California Desert Planning Staff in the Riverside BLM District. Total population size was estimated by attempting to enumerate all individuals within a smaller defined area. At each study site, the perimeter of an area encompassing 2.5 ac was flagged at 10-m intervals. Each plot was surveyed approximately 8 hr a day for a week each season. One to three people walked systematically back and forth across the plot, capturing lizards by hand or with a noose. Captured animals were marked by toe-clipping. At least two toes were clipped, but the long fourth toe on the hind foot was not removed. Digits already missing were incorporated into the new mark. Information recorded for each lizard included the individual's number, snout-vent length and tail length to the nearest millimeter, sex, and weight to the nearest 0.5 g. Before release, a small dot of Vanguard lemon yellow acrylic artist's paint was placed on the dorsal tail base to avoid recapturing the lizard that week. Estimates for the study areas were applied to larger areas having the same vegetation or habitat type.

Additional considerations in reptile (or other) inventories include the following:

1. Sampling Seasons. If possible, reptile sampling should be conducted during all seasons of the year, at least where climes are suitable for year-round reptile activity. A single one-season inventory of a habitat site would leave many gaps in the knowledge of species occurrence or abundance for most species present. Inventories during spring, or when most young are being produced, are probably the most important, but only multiseason inventories will provide information concerning most important seasons and changes that occur in the various species for various reasons. Inferences on species occurrence and relative abundance for unsampled areas will be most accurate where multiseason sampling has been accomplished in the sampled habitat sites.

2. Advertising for Information. Good results can sometimes be obtained on species and general abundance in local areas by advertising for information in local newspapers and in schools. Large numbers of prople spend time outdoors, and some of them are sufficiently knowledgeable or have special interests in certain groups of wildlife to be able to identify many of the species correctly. Many identifications will be incorrect, but the effort will probably be worthwhile.

3. Preservation Techniques. All specimens which the trapper desires to retain for identification or as permanent specimens should be properly tagged and preserved. Herpetological Circular No. 1, 1976, "A Guide to Preservation Techniques for Amphibians and Reptiles," © by George R. Pisani, published by the Society for the Study of Amphibians and Reptiles, is an excellent publication to use in preparing study specimens.

4. Identifying Specimens. There are many opportunities for assistance in identifying specimens. Local authorities are sometimes available; they may be either amateur or professional herpetologists, and may have good collections of available specimens. State wildlife agency personnel who live in the area are sometimes familiar with all local species. State or local museums usually have collections that can be compared with trapped specimens. Local biology teachers may be able to assist with identifications and, if necessary, specimens may be shipped to the National Fish and Wildlife Laboratory, Fort Collins, Colorado, for identification. It is advisable to make contact with personnel in universities, museums, or other institutions by telephone prior to shipping specimens. They will advise whether or not they have time to do the work and may offer special shipping or preservation instructions.

5. Comparing Different Standard Habitat Sites. It is recommended that some kind of diversity index or species richness value be calculated for each habitat site for comparative purposes. Diversity indices for each site may be calculated by the Shannon-Weiner information equation (Krebs, 1972). Where there is a high diversity, the observations are evenly distributed among the categories of the species. A habitat possessing a low species diversity has most of the observations occurring in one or a few categories (species). The diversity values indicate whether the habitat is supporting a diverse or meager fauna. Generally speaking, habitat stability and complexity increase with increasing diversity. Quantitatively, diversity (H') is measured by Shannon's formula (Shannon, 1948):

$$H' = \sum_{i=1}^{k} p_i \log p_i \quad \text{where}$$

p_i is the proportion of observations ocurring in the i^{th} species. The diversity index is the ratio between the number of species and the number of individuals found in an area. Refer back to the section on Diversity Index for additional discussion on interpretation of diversity in natural communities.

AMPHIBIAN INVENTORIES

There is a great variety of amphibians found on the public lands, with a great diversity of habitats. During heavy rains and wet seasons, amphibians may be found crossing highways and roads where they may be easily collected. However, they are normally sought in their preferred habitats, which are springs, seeps, desert ponds, lakes, moist woodlands, etc. Some amphibians are largely terrestrial except during the breeding season when they return to the water.

For the purpose of this Technical Note, amphibians are sorted into two groups and then further subdivided according to whether they are primarily terrestrial or aquatic. Table 4 summarizes some inventory methods by group.

1. Urodeles (Salamanders). Techniques for finding salamanders will depend on whether one is searching for aquatic or terrestrial species. The appropriate habitat to search depends both on the species expected and the time of year. Field guides should be consulted for information on when, where and how to look for each species. Some salamanders are entirely aquatic, while others are entirely terrestrial. Most western species are terrestrial for most of their lives, returning to water during the breeding season. The best time to find these species is when they congregate at breeding pools. The most difficult time to find any salamander is during dry seasons, when they disappear into inaccessible retreats.

Western Urodeles Habitats

Mainly aquatic	Mainly terrestrial, breeds in water	Entirely terrestrial
Ambystomidae: Dicamptodon spp. Rhyacotriton spp.	Ambystomidae: Ambystoma Salmandridea: All	Plethodontidae: All

2. Anurans (Frogs and Toads). The Anura may be separated into aquatic and terrestrial species. The western species of Ascaphidae (tailed frogs) and Ranidae (true frogs) are highly aquatic, seldom venturing more than several yards from water. Hylidae (tree frogs) are somewhat less aquatic than other frogs, often living where surface water vanishes seasonally and may travel farther from water. One hylid, the burrowing tree frog, is highly terrestrial. The species of Bufonidae

Table 4. Inventory Methods For Amphibians.*

Amphibian Inventory Techniques		Urodeles		Anurans	
Method	General notes	Aquatic habitats	Terrestrial habitats	Aquatic species	Terrestrial species
1. Road riding	Evenings after rains near water		G/E	G	E
2. Listen for choruses	Evenings (most species); especially after rains	(All species voiceless)		E (Ascaphus, R. boylei, & R. muscosa are silent)	E (B. boreas is silent)
3. Walk along shores/banks	Day or night	G (breeding season only)		E (day or night throughout activity season)	F (usually concealed in day, vocal at night)
4. Eye-shining	Good aid to #2 & 3		G	G	G
5. Search for eggs/tadpoles	Some species concealed; consult field guide	P (secretive)		E	E
6. Netting, seining, dredging		F? (secretive)		G (tadpoles & adults)	G (mainly tadpoles)
7. Electroshocking	Amphibians sink!	F (generally concealed)		F/P	F/P
8. Pit traps with drift fence	Best near breeding sites		E	F/P (ranids good jumpers, hylids good climbers)	E
9. Funnel traps	Aquatic equivalent of #8	G (Rhyacotriton, possibly others)		G (tads & adults)	
10. Turn rocks, logs, moss, etc.	Good if substrate is moist; always replace!	G	E		G (for newly transformed toadlets near water)
11. Tear apart decaying logs	Not advised—destructive to habitat!!		E (see general notes)		
12. Shoot				G (for wary frogs)	
13. Advertise	Can yield excellent results; see text				

Table 4. Inventory Methods For Amphibians (Cont'd.)*

Amphibian Inventory Techniques		Urodeles		Anurans	
Method	General notes	Aquatic habitats	Terrestrial habitats	Aquatic species	Terrestrial species
Special Techniques a. Search beneath lights	Where and when insects are attracted				G (for some bufonids)
b. Search tree cavities			F (Aneides lugubris)		
c. Fishing with baited hook		G (for some species)		F (some frogs)	
d. Dissect woodrat nests			F (Ensatina, possibly others)		
e. Search for open burrows					F (spadefoot burrows distinctive, but difficult to find)

*Key: E - Excellent F - Fair
G - Good P - Poor
(No symbol) - Forget it!

(true toads), Pelobatidae (spadefoot toads) and three Mexican border forms (the burrowing tree frog, the Leptodactylidae or barking frogs and the Microhylidae or narrow-mouthed toads) are mostly terrestrial visiting water mainly to breed. The degree of terrestriality varies from that of the Colorado River toad, which usually remains within a mile of permanent water, to Couch's spadefoot toad, which lives up to several miles from water and breeds exclusively in ephemeral pools.

Western Anurans Habitats

Mainly aquatic	Mainly terrestrial
Ascaphidae: All	Hylidae:
Hylidae:	*Pternohyla*
Acris	Bufonidae: All
Pseudacris	Pelobatidae: All
Hyla	Leptodactylidae: All
Ranidae: All	Microhylidae: All

Before going into the field to do inventories, perform the necessary background work. Briefly:

1. Compile existing information from available literature, museum records, and knowledgeable persons.

2. Compile a hypothetical list of species expected in the study area with the use of field guides, including all species already known to be present.

3. Determine the appropriate combination of inventory techniques (including when and where they should be used), using information in the field guides and contained in this publication, to verify the species on the hypothetical list.

Inventory Techniques Description

1. *Road Riding*. Drive slowly along secondary or backcountry roads at night. (The appropriate speed depends on road condition and the expertise of the observers.) Ideal conditions consist of clean pavement with narrow shoulders and no curbs, during or shortly after rains, and near water. Under these conditions many salamanders, frogs, and toads will be foraging and migrating to breeding sites (during appropriate seasons) and are easy to see on clean pavement. During very wet periods, even ranids disperse overland.

2. *Listening for Breeding Choruses*. Most anurans have a loud and distinctive mating call (exceptions in the western states are *Ascaphus truei*, *Rana boylei*, *R. muscosa*, and *Bufo boreas*). Choruses of even a few can be heard for 1/4 of a mile or more. An effective method is to visit known streams, ponds, and lakes on warm evenings (most species call at night). In less familiar areas, drive along roads at night and periodically stop the engine to listen (engine noise drowns out distant choruses). Rainfall stimulates breeding activity, especially in arid

regions. Don't ignore temporary ponds; several amphibians, (some of them exclusively) breed in them.

3. Walking Along Shorelines and Streambanks. This can be done either day or night. Many salamanders congregate in or near ponds and streams during the breeding season and are fairly conspicuous at this time. True frogs and tree frogs typically spend the day near the water's edge and will leap into the water when disturbed. True toads and spadefoot toads are mostly secretive and spend the day concealed from view. Exceptions are the diurnal toads : Bufo canorus, B. boreas exsul, and alpine populations of B. boreas. Newly transformed toadlets of some species are diurnal and can be found near shore in morning or afternoon (e.g., Bufo punctatus, B. debilis).

4. Eyeshine. Amphibians' eyes reflect light well; this eyeshine is easily seen on moonless nights. It can be detected from up to 100 ft or more with a bright flashlight. It is important that the light source is held close to the observer's eyes; a headlamp thus works well. With practice, one can distinguish amphibian eyeshine from that of insects and mammals.

5. Searching for Eggs and Tadpoles. The effectiveness of this method varies greatly for different species. Most salamanders' eggs and larvae are carefully concealed. Eggs of many anurans are laid in conspicuous masses or strings. Nearly all anuran tadpoles are easily seen if the water is clear. Identifying genus is easy with a magnifying glass, but it is often difficult to distinguish between congeneric species.

6. Netting, Seining, Dredging. These are variations of a basic technique; the agility of the quarry, the width and depth of the water, and the amount of vegetation and debris present determine which method is best. Care must be taken when using these methods where specimens cannot be seen. Secretive species under rocks or in bottom mud and fast swimmers may not be caught by haphazard netting or seining.

7. Electroshocking. This is not as effective as it is with fishes, because amphibians sink when stunned. Therefore, it is not likely to be successful except in clear, shallow water.

8. Using Pit Traps. Various kinds of pit traps are described in the literature (see BLM Technical Note No. 299) and the discussion on reptile inventories). The catch is greatly improved if drift fences are erected leading to the pit. Success is also improved if pits are placed where amphibians congregate, specifically near breeding ponds and streams in the appropriate season. It is an excellent method for trapping salamanders, true toads, and spadefoot toads. It works poorly for frogs, which can jump out of all but the deepest pits, and tree frogs, which can climb nearly anything. However, even these latter groups can be successfully collected if the pit is partially filled with alcohol or formalin.

9. Using Funnel Traps. The effectiveness of this method depends greatly on the animal's mobility. It has been found to work well for Rhyacotriton, possibly other salamanders, tadpoles, and aquatic anuran adults. Since terrestrial anurans spend little time in water, pitfall traps on land are more productive.

10. Turning Rocks, Logs, Moss, etc. Many species spend the day on the surface of the ground beneath objects, if there is moisture. Looking under such objects is an excellent way to find salamanders, both on land and in clear shallow water. True frogs and tree frogs generally don't use such shelters. True toads and spadefoot toads usually retreat into burrows and deep crevices. However, for a short time after transforming, toadlets can be found near the shore beneath rocks, cow dung, in cracks in drying mud, and any other moist shelter from the sun.

11. Tearing Apart Decaying Logs. These are excellent places to find salamanders during their activity season. However, it irreparably destroys the habitat and is unjustifiable, except perhaps where rotten logs are abundant.

This search method and also method number 10 can be very destructive to habitat; ALWAYS REPLACE ALL OBJECTS TO THEIR ORIGINAL POSITIONS.

12. Shooting. Shooting with dust or bird shot is an effective way of capturing wary frogs. However, one must see the frog first, which is usually the most difficult part of the inventory. It is pointless to shoot any other amphibians, since once seen, they are easily caught.

13. Advertising. In the right circumstances, advertising can yield excellent results; the criteria necessary for success are:

a. The audience reached should be one that lives near or frequents natural habitats. An ad in the L.A. Times, for instance, will probably be unproductive (unless one is looking for slender salamanders or alligator lizards, which live in suburban gardens). Good places to advertise, and people to reach, are: rural or school newspapers/students, bulletin boards at nature centers, wildlife reserves, trailheads, etc.; and memos to park rangers, fire crews, naturalist/hiking societies, etc.

b. The species being sought must be easily recognized by laypersons (Many people don't know the difference between salamanders and lizards). The animal should therefore be of unusual size, shape, coloration, etc., and should be precisely described in nonscientific language. Examples of specific animals to advertise for are: Pacific giant salamander (large size), red-legged frog (only frog in area with red), and tortoises (unmistakable form).

c. The best subjects to advertise for, in addition to being recognizable, are those which are so rare or secretive that even an intensive inventory is unlikely to verify their presence. If they do exist in an area, a local resident will find one sooner or later.

BIRD INVENTORIES

Birds are valuable to man for a variety of reasons, e.g. esthetic (photography, bird-watching, sport hunting of game birds, etc.), economic (consumers of vast numbers of insects and rodents), scientific, and ecologic. For these reasons it is advantageous to attempt to preserve and manage bird species. However, management is very haphazard unless the manager is reasonably knowledgeable on the occurrence, life requirements, and interrelationships of the species he wishes to manage. Each new study on avian ecology substantiates the fact that the lives of birds and associated fauna and flora are inseparably intertwined in many subtle and complex fashions. Often the existence of one species completely (or largely) governs the survival of another. By themselves, surveys are not designed to demonstrate ecological relationships between species. They do, nevertheless, provide the framework from which interrelationships may be postulated and eventually proven or disproven.

Many species of birds, small mammals, reptiles, etc., prefer habitats containing specific characteristics of vegetation type and structure (growth form, height, etc.) in conjunction with other environmental features. The greater the variety in vegetation type and structure, the greater the variety and number of bird species that may live on a particular piece of land. The more knowledge biologists have on specific species habitat requirements, the more efficiently they will be able to conduct bird and other animal inventories. Some birds, for example, prefer selected vegetation species of certain heights for nesting. To the casual observer, a sagebrush-covered valley may look fairly homogeneous as far as composition and structure are concerned, but detailed examination reveals many subtle variations that birds and other animals respond to. Hence, casual observations or minimal sampling often fail to reveal the more important areas of seemingly "homogeneous" habitat. Only fairly intensive animal surveys and analyses of habitat relationships will provide the information from which accurate conclusions can be drawn. Such relationships should be investigated on a continuing basis as time and other priorities permit. In time, many of these relatively inconspicuous ecological relationships will undoubtedly be found to be of high importance to man and other life forms.

It is recommended that observed nest locations be mapped during the inventories for bird species occurrence, as this will provide additional information on habitat preferences. Some species will nest in a variety of sites, while others are extremely selective. Ferruginous hawks in Utah, Wyoming, Colorado, Idaho (and other states) will commonly nest on the ground, on large rocks or rocky upthrusts, on cliffs, monuments, other manmade structures, and in a wide variety of trees and shrubs. However, in the same areas, Swainson's hawks nest almost entirely in trees. Golden eagles nest predominantly on cliff ledges, while bald eagles nest mostly in tall trees and dead snags.

Some bird species nest only (or predominantly) in riparian zones. Deterioration of riparian habitats due to livestock grazing or other causes may totally remove crucial nesting habitat for these riparian-specific species. Determining preferred nesting habitat sites for the predominant species in an area, along with the species occurrence information, provides valuable data that may be used in making land management decisions. Primary emphasis should be given to mapping nesting sites of birds of prey, colonial waterbirds, colonial terrestrial species, or other unique, endangered, threatened birds or other birds having special State or national interest.

Inventory Preplanning and Inventory Levels

During inventory preplanning stages the biologist should determine the types and amount of bird data needed to accomplish the objectives of the inventory. The level (intensity) of the inventory will usually be based on the importance of the species thought to be present and the probable impacts on them from the proposed land uses. However, the existing data base for most public lands is fairly sparse, so we recommend a minimum of Level II inventories wherever funds, manpower, and time permit. This will help to build a data base for the different SHS's from which predictive capabilities will be developed and also a better capability for analyzing interrelationships between flora and fauna.

The following guidelines given are for using the various methods discussed in the Technical Note for different levels (intensity) of inventories (Refer to Table 1).

Level I. Conduct a thorough literature review of all available reports and documents pertaining to the area of concern; check museum records; visit with personnel of State wildlife agency and other agencies; visit with recognized experts; keep track of species observed during routine fieldwork.

Level II. Accomplish work suggested for Level I; set up and run transects, plots, or other methods in at least two habitat sites (i.e., SWA's) per SHS (i.e., stratum) and for at least two seasons expected to yield the best species occurrence and population information.

Level III. Accomplish work suggested for Level I; set up and run transects, plots, or other methods in at least four habitat sites (i.e., SWA's) per SHS (i.e., stratum) during each season of the year.

Level IV. Accomplish work suggested for Level I; set up and run transects, plots, or other methods using a statistical sampling design for a minimum of two years in all seasons to obtain results within predetermined confidence intervals.

Procedures for Conducting Bird Inventories

In those areas where soil and vegetation mapping has been accomplished in accordance with BLM Manual Section 4412, all bird inventories should be conducted within the delineated mapped areas for SWA's. Bird species occurrence and relative abundance (or estimated density) will be obtained within these fairly homogeneous vegetation units. By so doing, the vegetation and soils information can be better related to the bird species found there. Any of the methods described in this Technical Note or other acceptable methods can be utilized for sampling within the SWA's, depending on the size of the SWA and the sampling intensity desired.

In areas where SVIM mapping has not been accomplished, the biologist should obtain maps and aerial photographs for the area(s) of concern and delineate mapping units, based on homogeneous vegetation, which can then be sampled for the presence of the desired groups of animals. Following are some points to be considered prior to commencing any inventories:

Map and Photo Studies. Study all available maps and aerial photos pertinent to the study area. Vegetation maps are valuable in depicting the types of vegetation which different bird species prefer. Aerial photographs, especially when used with a 3-D viewer, bring out both terrain features and vegetation types. Studying cliff lines and rocky outcroppings provides good insight as to where eagles, prairie falcons, peregrine falcons, kestrels, red-tailed hawks, cliff swallows, swifts, etc. may be nesting. Aerial photographs supply other information relative to vegetation composition, density, and structure from which to estimate bird species present.

Aerial Surveys. A brief aerial survey of the area to be studied gives the biologist a rapid overview of the vegetation types present and the types of terrain and vegetation present in contiguous areas. Unless they are already familiar with the area, such an overview quickly establishes in observers' minds the approximate area in which they want to construct their transects or plots to obtain the most representative data. Flights prior to raptor nesting surveys are especially valuable in rapidly providing knowledge on the size, structure, and/or suitability of rocky outcrops or cliff faces for raptor nests, or riparian vegetation for tree or shrub-nesting species. The presence or absence of trees suitable for nesting and/or roosting is quickly discernable.

Ground Surveys. Ground surveys are necessary for most species of birds, except possibly colonial water birds and sea birds, whether preliminary aerial surveys are conducted or not. The ground surveys may consist of methodical examinations of all potential raptor nesting sites based on the specific habitat preferences of each species, or they may consist of planned transects or plots conducted in specific vegetation types to discern species and estimate breeding pairs of birds in a local community. In any event, the survey type conducted requires considerable thought and planning to achieve the specific inventory objectives.

Timing of Surveys. Actual timing of surveys is extremely important, both seasonally and daily. Throughout much of the West, there is a peak in the breeding season which normally occurs sometime between early May and late June. Where such peaks occur, conduct the censuses/inventories at, or near, the peak in breeding activities when most breeding birds are on their breeding territories. The periods of peak nesting activities for different species can generally be obtained from bird guides or local authorities. Many species of desert birds spread their nesting activities over a considerable period of time. In such areas, conduct inventories during representative periods.

Bird Species Identification. To conduct bird surveys of any type, it is essential that the observers be able to identify the various bird species found in the area. Biologists who are not knowledgeable about bird identities in their districts and/or resource areas should spend time in the field identifying birds with the help of a good pair of binoculars and a good bird guide. Checklists may be available from other agencies, such as the State wildlife agency, U.S. Fish and Wildlife Service, U.S. Forest Service, U.S. Park Service, or from Audubon bird clubs, which will list the birds to be found in specific areas. No training can substitute for experience in the field.

Selecting Inventory Site. The sites selected for conducting bird inventories should represent the vegetation types for which data is needed. Including several vegetation types within one transect or sampling plot should be avoided. Such areas would include considerable "edge" that might not represent the total area to which the results may be applied. Edges, or ecotones, normally include bird species that may not occur in homogeneous vegetation types. Where the sites are suitable, those used for vegetation transects or soil samples should also be used for bird studies.

Recording of Data. Record data on the forms included in this Technical Note, or on equivalent forms developed by the district/area biologist. The bird species observed in the area should be recorded on Form 6602-1 (BLM Manual Section 6602, Illustration 1). Give names of animal species, occurrence by habitat site, and names of special features on Form 6602-2, Special Habitat Feature, as described in BLM Manual Section 6602 (Illustration 2).

Inventory Reliability. Reliability of surveys/inventories depends largely on the biologist's judgment in conducting transect or plot counts on "suitable" days (days when weather, nearby disturbances, etc., will not alter bird behavior in ways which will make them less discernable), and conducting adequate "runs" through an area to be sure most of the bird species have been observed and counted.

Available Data. Make a complete search of available bird information in the proposed study area before starting fieldwork. The data needed may be available in a master's thesis or other source. The primary data elements needed for bird inventories are:

1. Birds of each species per 100 acres (or 100 hectares) for passerines (by habitat type).
2. Birds of each species per colony (colonial species)--either from total count or from sampling.
3. Nesting pairs of raptors, by species, in the planning unit or resource area.

SURVEY METHODS

Several standard bird survey/inventory methods are discussed below for the different bird types found on public lands. Area and/or district biologists should select the method of inventory or census to be used, depending on the type of area and birds involved, manpower, money availability, and specific objectives to be met. Specific methods should be prescribed for any contracts awarded for accumulating bird data.

Selecting Bird Inventory/Census Method. Birds are grouped into the following broad categories for conducting surveys and/or inventories:

A. Terrestrial Species (excluding birds of prey, including game birds).

B. Birds of Prey (raptors). This group of birds is discussed only generally in this Technical Note since they are covered in Technical Note 316.

C. Marsh and Shore Birds.

D. Colonial Water Birds.

E. Sea Birds (marine and pelagic).

Inventory (survey and/or census) methods for the different groups are discussed below.

A. Terrestrial Species.

1. Territorial and Noncolonial Passerines.

a. International Bird Plot Census Method. The International Study Conference on Bird Census Methods and Results was held at Hillerod, Denmark, in 1968. Following this conference a standardized

plot census technique was developed to establish annual indices of population levels, determine species composition of a community, and to estimate population densities. This method, which has been accepted in the United States, is suitable for territorial and noncolonial passerines (perching birds) and other species that have similar dispersion patterns and are essentially residents in a relatively small area, such as breeding bird populations.

(1) Establishing Study Plots.

(a) Study plots should be as near as practicable to a square. The minimum size should in general be 40-100 ha in an open habitat, or 10-30 ha in a closed habitat. Most BLM habitats, such as grasslands, prairies, tundra, sagebrush, saltbush, creosote bush, or other vegetation types that are generally less than chest high, would be classified as open habitats. Where shrubs or other vegetation obscure overhead or outward observations, the plot should be classified as closed canopy. The actual size of the plots may vary depending on the complexity of the community and its general level of density. However, a size of 42 ha for open habitats and 12 ha for closed habitats is recommended by the International Committee because of the ease of computing the number of birds per unit of area, such as birds per square kilometer. A given plot should be placed in a specific vegetation type rather than include several vegetation types; this minimizes "edge effect." The census of species using riparian zones is discussed in a separate section.

(b) Divide each study plot into 1-ha units (100 m x 100 m) or smaller size, depending on the particular area. These should be numbered (see Fig. 8). As shown on the diagram, it is desirable to place numbered stakes with bright flagging at the corners of the 1-ha plots. This enables observers to always know their exact location and enables observers in later years to find the exact study plots. By plotting the study units on aerial photographs and marking only the outside four corners, it is sometimes possible to omit the interior stakes.

(c) The exact study plot location depends upon the study objective. If the objective is to monitor long-term community relationships in a characteristic vegetation type, then the plot should be located where the chances of alteration are minimal. If the objective is to determine the impact of an environmental alteration, then the plot should be established in a location where an alteration will occur, but where at least two years of baseline data can be obtained first. One year's data is better than nothing, but the reliability of the data will not be as good.

(d) Describe the study plot and include the following data:

i. Location of the plot, latitude and longitude, relationship to existing towns and roads, mapping on aerial photo or topographic map, if possible.

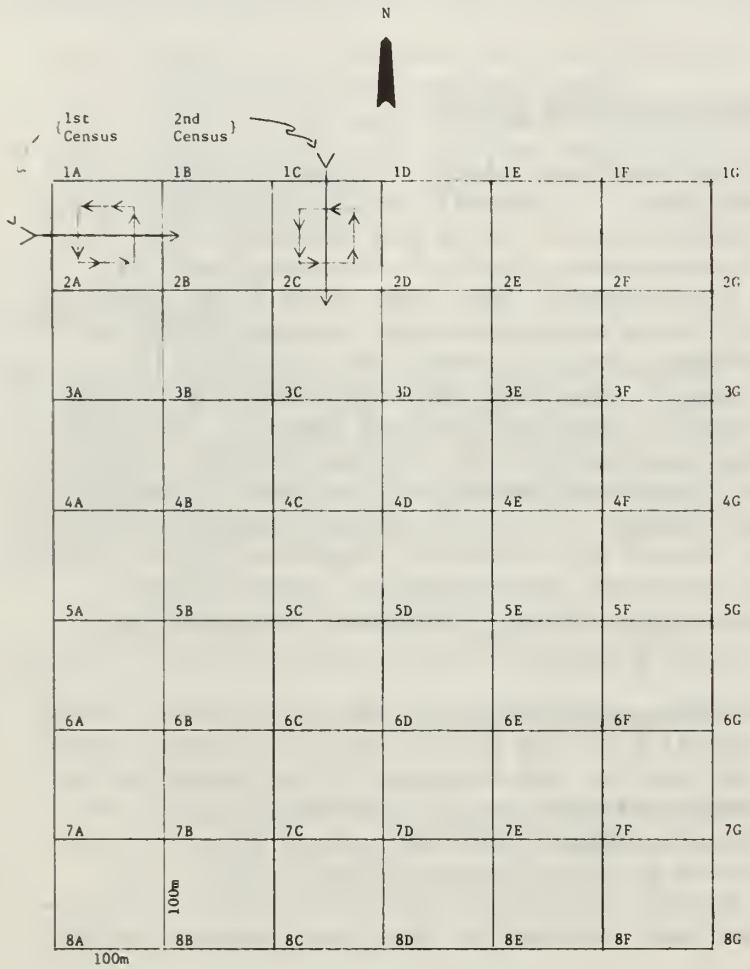

N
1st Census
2nd Census
1A 1B 1C 1D 1E 1F 1G
2A 2B 2C 2D 2E 2F 2G
3A 3B 3C 3D 3E 3F 3G
4A 4B 4C 4D 4E 4F 4G
5A 5B 5C 5D 5E 5F 5G
6A 6B 6C 6D 6E 6F 6G
7A 7B 7C 7D 7E 7F 7G
8A 8B 8C 8D 8E 8F 8G
100m
100m

Fig. 8. Spot Mapping Grid and Instructions.

INSTRUCTIONS

1. The grid pattern in this illustration shows a general layout for census conducted using the International Bird Plot Census Method (spot-mapping method). Depending on time and money available, area of habitat to be censused, etc., the grid squares r y be either 50 meters or 100 meters square. If the grid squares are 100 meters square, the total plot size is 42 hectares which is a desirable size for open habitats.

2. In setting up the plot, each of the grid corners should be flagged or staked so that the observer always knows his/her position in the plot and so that subsequent censuses can be conducted in an organized manner.

3. The censuser may begin at any point of the grid, so long as he/she systematically censuses all grids within the plot. In this example, he/she enters the first grid in the upper left-hand corner, completes a route as shown in the grid (or any pattern to be sure entire grid is covered) and then proceeds into the next grid square.

4. In the second (and subsequent) censuses, the observer should begin at a different point, such as shown on the diagram, and then work through the plot in a different pattern, again covering all grid squares.

5. The object of the census is to attempt to locate each individual singing male bird and to map its general territory. By multiplying the total number of singing males by 2, an estimate of the total number of birds, by species, in the plot may be estimated with fair accuracy.

ii. General landscape characteristics.

iii. Terrain elevation, if known, and slope characteristics.

iv. General statement about soil type.

v. A large-scale map of the gridded plot showing dominant plants and other important species in each 1-ha unit, where practical.

(2) Conducting the Counts.

(a) For a given study plot, at least five complete census runs are desirable. If solid information on density and composition is needed, a minimum of ten (10) runs should be made in closed habitats and eight (8) runs in open habitats.

(b) Conduct all counts between sunrise and 3.5 hrs after sunrise, the time when most bird singing occurs. However, if a few species are known to be present that sing most frequently or are otherwise more conspicuous at other times of the day, then special census runs may be made to include these species. Counts should not be considered when the wind exceeds 10 mph; the sky is more than 50 percent overcast; it is foggy, or precipitation has been recorded within one hour of the beginning or the end of the census run. Under these conditions bird activity and singing are much reduced.

(c) Time census runs around the peak of nesting. This can vary between areas, but in general, late May through early June is best. If possible, three winter counts should be conducted in January to determine winter species using the area.

(d) Before counts are made, spend enough time on the study plot to learn the main bird species in the area. Again, this should not be too difficult for even a relatively inexperienced bird-watcher. There will usually not be over 20 to 25 species present for most western rangeland plots, and not more than 30 to 50 species present in other preferred bird habitats.

(e) In conducting a census run, enter the first 1-ha unit and go through it as shown in Figure 9. By following the interior route shown in the illustration, you will always be within 25 m of any part of the unit. When hearing or seeing a bird which is not identifiable, approach close enough to recognize it, if possible, and continue with the prescribed route. Other patterns of travel through the plot may be used if the observer believes these patterns will be more efficient for the particular area. The goal is to plot the location of all birds in the units, using the international Bird Plot Census and the coding system described under Figure 10. When finished with the preceding 1-ha unit, enter the next one and repeat the procedure. Do this for all 1-ha units in order; this can be accomplished in one or two mornings. Two visits should normally not be made on the same day.

Date June 10, 1979 Habitat Type Big Sagebrush

Time of Initiation 6:00 a.m. Temp. 65° F. Wind 0

Time of Completion 9:15 a.m. % Cloud Cover 30 %

T 12N R 6E S 21

Plot Location 300 yds east of radio tower Census Taker Yull, P.

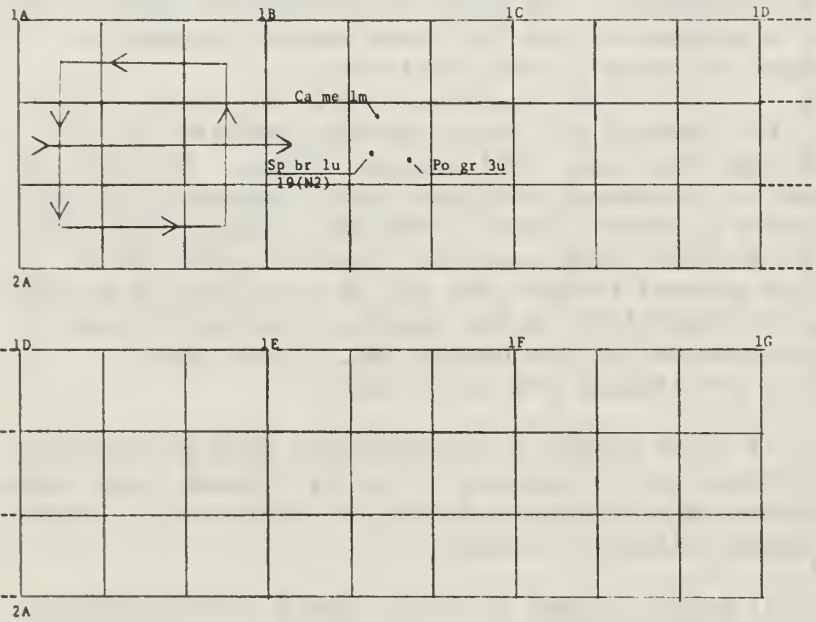


Fig. 9. Spot Mapping Census with sample plot data. (International Bird Plot Census Method)

INSTRUCTIONS

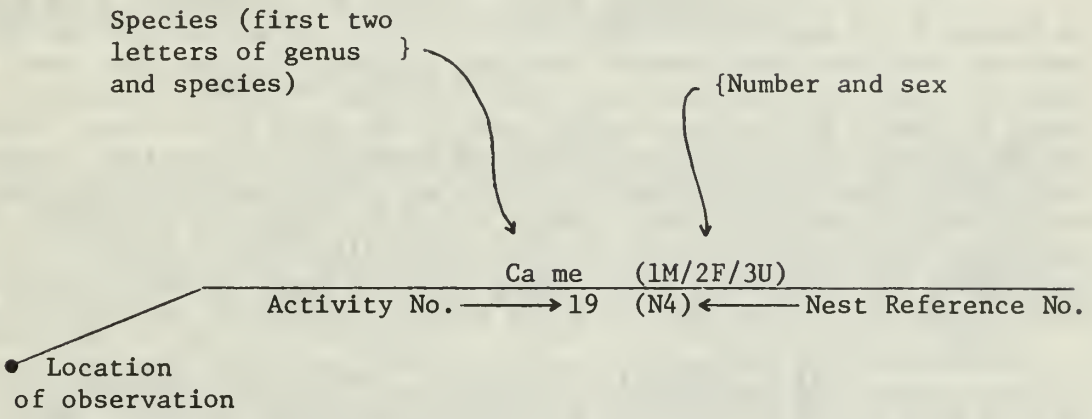
1. Following a predetermined census route, the observer walks through each grid and plots all birds observed in their respective locations within the grid. Coding symbols are used to show species, sex, number, and behavior and nest information. Some recommended codes are provided on back.

2. After the planned number of censuses have been conducted, determine the total number of separate breeding pairs by observing the plotted territorial patterns.

3. The goal of the spot-map method is to determine the number of territories encompassed by the plot for each species. During the breeding season, each male establishes a territory which he actively defends primarily by singing a species-specific song, and to a lesser extent by other displays. Most species are intra-specifically territorial, defending the territory against only members of their own species. Breeding bird density for a species is derived by multiplying the number of territories of that species by 2. This method is primarily applicable during the breeding season. A transect method should be used at other times of the year.

Fig. 10. Format and Code Used in Recording Avian Census Data During Spot Mapping Census [1/]

(International Bird Plot Census Method)


Species (first two letters of genus and species)
{Number and sex
Ca me (1M/2F/3U)
Activity No. → 19 (N4) ← Nest Reference No.
Location of observation

No.	Activity
1	Species observed in breeding season.
2	Species observed in possible nesting habitat (one or more individuals where pairing status is unknown or non-existent).
4	A pair observed in suitable nesting habitat.
6	Territorial behavior, display and courtship.
7	Visiting probable nest site. (Includes visitation for new nest site and departure from probable but unseen nest site).
10	Nest building.
11	Agitated behavior and distraction display by adults suggesting nest or young nearby.
13	Unfledged young independent of nest or recently fledged young.
19	Nest with adult seen incubating or nest with eggs or young seen or young heard.

1/ From Diem, K. L. A handbook of biological techniques, Wyoming Game and Fish Department, Cheyenne, Wyoming (draft manuscript).

(f) Start the second and remaining census runs at different locations and take the 1-ha units in different order. For instance, if starting at unit 1A (Figure 8) and working east, then back west, on the first census run, start at 1F and work south on the second run. When a census is repeated on the same plot in a later year, the earlier year's pattern should be followed as closely as possible.

(3) Recording Data. Prepare an appropriate form such as Figure 9 and use for recording observations. Label each of the six units on the form to correspond with the grid map (1A, 2A, etc.) and to show the order in which the units were surveyed. Use the notations shown in Figure 10 to plot observations on the above data forms. (This system is standard throughout the United States.) The species' common name rather than the abbreviation of the genus-species scientific name may be used on the data form. Invent codes for other activities if necessary, especially if dealing with nonbreeding birds. Some biologists use a separate spot mapping form for each species of bird encountered so that the data does not become confused on the form.

(4) Evaluating the Data. Tabulate and analyze all data so that direct comparison can be made with other studies. Make calculations only for those species which were recorded on at least two of the census runs. It is impossible to determine the status of a species recorded only once, i.e., the low observation rate implies that a species is either especially scarce or very hard to observe. All species, however, should be recorded as observed. They are all important in terms of species composition. If only one pair of a species has been observed on the study area, use caution in trying to project the number of individuals of this species on a larger area; the one recorded pair may be the only one on a very large area.

(5) Subsequent Surveys. Survey a given plot for at least two years to detect inherent population changes. Obviously, the surveys each year should be similar. For instance, try to do the counts on approximately the same dates and under the same weather conditions.

(6) Method Advantages. One advantage of this census method is that it is widely used on an international basis, which allows for comparisons to be made among many studies. This is obviously not possible when researchers use a diverse group of census methods. Undoubtedly, another of the major advantages of this procedure is that it can be used by people with limited avian experience. In fact, data obtained are comparable with a wide range of observers' abilities. In contrast, other techniques require observers with considerable ornithological experience. For instance, to produce valid data with the Emlen transect method, the observer must know bird calls and be able to estimate distance quite accurately.

(7) Method Disadvantages. Compared to other census methods, such as the Emlen transect, the plot census takes more time. For instance, it takes up to two days to stake out a plot, if this is necessary. It then takes from five to ten mornings to complete the

actual counts depending on the number of runs and the vegetation type involved. With an average of five complete runs, the plot census yields good data on species composition and relative population levels, but it does not always yield adequate data on densities. Using this technique, the only way to get valid density data on all species is to substantially increase the number of runs and spend a good deal of time on the plots locating nests. Density values are especially hard to get from this technique with species that are relatively scarce and/or inconspicuous or for species that are relatively dense.

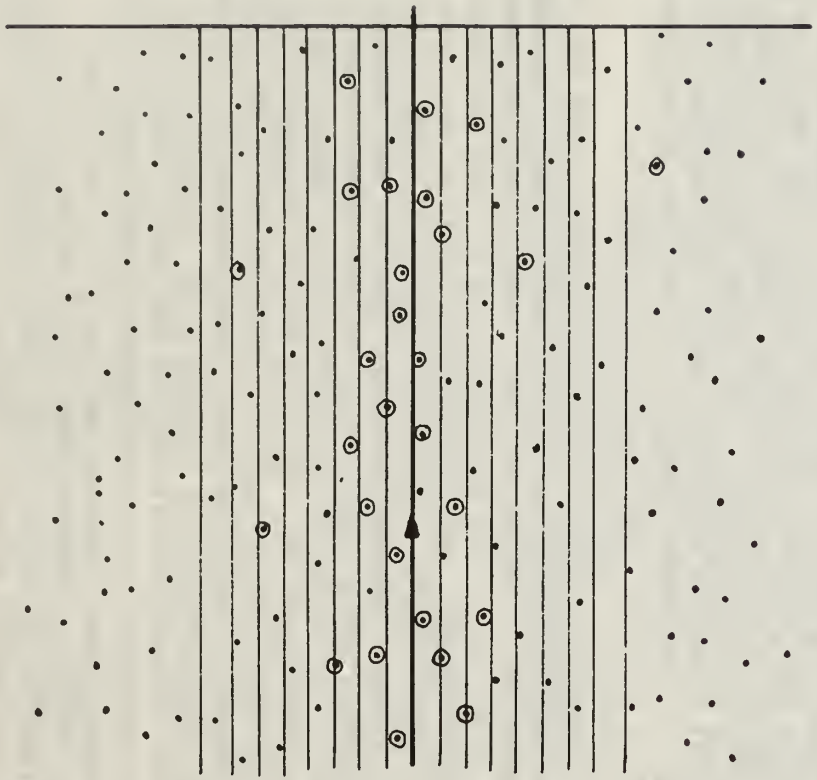
b. Emlen Transect Method.

(1) Type of Data Recorded. This method is recognized by field ornithologists for its accuracy and efficiency in determining bird abundance. It is known as a variable strip transect because birds are recorded in a number of strips that are of different widths, lying parallel to the center line that has been established for the transect. In this method, the observer walks slowly along the transect and records individuals by species, observed or heard, according to their perpendicular distance from the transect route. Estimating such distances fairly accurately requires some practice. Additional data which should be recorded include whether the bird is a territorial male, sex (if possible), and age (fledgling vs. adult).

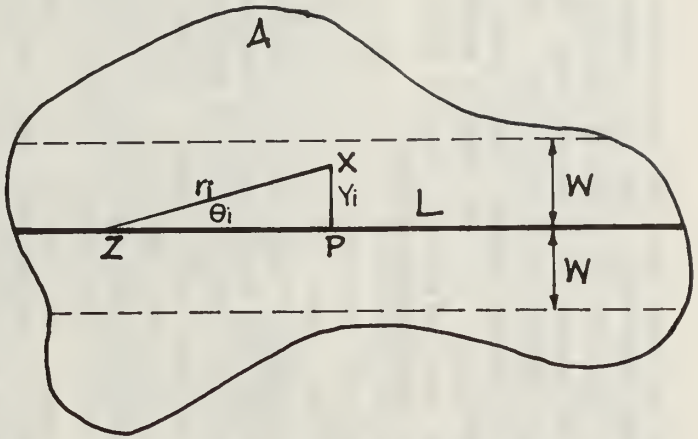
(2) Establishing a Transect Line. Establish the transect line in a homogeneous habitat well within the boundaries of such habitat to minimize edge effects. If the length of the transect is 4 km and 125 m are sampled on either side of the transect, the results will represent number of birds per 100 ha. If a 1-mi transect is run, censusing 412 ft (126 m) on either side, the results are in terms of number of birds/100 ac. Conversion from acres to hectares or vice versa is quite simple (2.47 ac = 1 ha). See Figures 11 through 14.

(3) Width of Strips. The width of strips from the center line varies between observers and type of habitat being sampled. The author of this method, J. T. Emlen (Auk 88:323-342, 1971) suggested strip widths of 0 to 50 ft, 50 to 100 ft, 100 to 200 ft, and 200 to 412 ft. By utilizing a total transect width of 824 ft (412 ft on each side of the center line), results can be quickly calculated in terms of birds per 100 ac. However, current research indicates that for most western rangelands more appropriate strip widths would be (from center line), 0 to 10 ft, 10 to 25 ft, 25 to 50 ft, 50 to 100 ft, 100 to 200 ft, and 200 to 400 ft, as shown in Figure 12. By using strips of these widths, the point at which bird observations begin to drop off can be detected more quickly. The distance or strip in which bird detectability begins to decrease sharply is called the basal plateau level and is used in calculating coefficient of detectability (C.D.) and total birds in the transect. Unless the biologist is an experienced ornithologist who has had experience in running Emlen transects and has a fair knowledge of bird detectability in different habitat types for different species, it is recommended that these strip widths be utilized. Examples of calculations of C.D. and bird density shown in Figures 13 and 14 have used these strip widths.

Fig. 11. An Example of the Variable - Strip Transect Method
(from J.T. Emlen, Auk, 1971 p. 328-329)



Schematic model of a stand of vegetation with randomly scattered birds (dots) bisected by a transect route (median line). Dots representing birds that are detected by eye or ear are encircled in the model. Lines parallel with the transect route at 50-foot intervals define strips of coverage.



The unit to be censused has area A. The transect length is L and the transect width is 2W. Z is the position of an observer when a bird is detected at X. P is the point on the line which is perpendicular to the object. The sighting distance is r_i, the sighting angle is θ_i, and the perpendicular distance from the object to the center line of the transect is y_i. W can be left unspecified or effectively infinite or can be a fixed, finite constant.

(4) Coefficient of Detectability. To make calculations of density, derive a coefficient of detectability (C.D.) for each species observed and/or detected on the transect. The C.D. represents the proportion of the population which an observer can detect (either visually or aurally) while running the transect; it varies with species and habitat. Some birds, such as robins, bluebirds, meadowlarks, red-winged blackbirds, etc., may be almost totally observed while more shy and retiring birds such as the wood thrush, ovenbird, green-tailed towhee, rufous-sided towhee, and other birds that feed mostly on the ground in shrubby areas, will not be totally observed, even in the first relatively narrow strip adjacent to the center line of the transect. The detectability factor will vary between about 1.1 and 2.5 for most birds found on public lands. The method for calculating this factor is shown in Figure 14.

(5) Conducting the Census. The Emlen variable strip transect method can be used at any time of the year. As in the spot-map method (International Bird Plot Census Method), the most appropriate time to conduct the census is from sunrise to about 3.5 hr after sunrise. The observer should travel along the transect at a speed of approximately 1 to 2 mph in open country and 1/2 to 1-1/2 mph in more forested situations (areas of closed canopy).

(6) Rerunning the Census. Weather permitting, sample each transect a minimum of three times, preferably on three consecutive days. However, in moderately dense or very dense habitats, a census of six or more consecutive days is more accurate. This is especially true with regard to species in low densities, some of which may be missed altogether if only three censuses are conducted. Determine an average of the results for each species. During the breeding season, sample a minimum of three times per month (or more in denser vegetation), with the days as close together as possible. Average results over the entire breeding season unless a particular species has a pronounced density peak for a given month. If so, use this peak density value.

(7) Suitability for Various Bird Species. The variable strip transect method is appropriate for most terrestrial species such as doves, hummingbirds, woodpeckers, and passerines in general. However, according to Emlen, it is not useful for "wide-ranging water birds, shorebirds, hawks, nocturnal birds, for treetop birds in tall dense forests, and for swifts and swallows that cruise about above the vegetation."

(8) Recording the Data. Use the form, Field Data Sheet-Strip Census (Fig. 12), for recording the data. Birds flying over the transect area are not recorded unless they are actively foraging or searching for food. Habitat usage should be noted. To determine the exact length of the transects, the route of each strip transect should be plotted on an aerial photograph, and the length measured on the photograph, followed by appropriate conversion to meters. Transects should be flagged to permit recensusing.

Fig. 12. Field Data Sheet - Strip Census

Project *Piceance Basin Oil Shale* File No. *80 1*

Sheet No. 1 of 1

Transect # 3 Vegetation Type *Sagebrush* Sample Period *6/15*

Date *6/15* Time (24 hour) *0715* Temperature (°C) at Start *6*

Wind (Beaufort Code 0) *1* Sky Condition Code # *1* Observer *BH*

Comments: *Great to be in the field again.*

Species	Code	Number Observed per Strip						Fly Over
		0-10'	10-25'	25-50'	50-100'	100-200'	200-400'	
Brewer's Sparrow	*SpBr*	••	•••	•••••	•	••		

INSTRUCTIONS

1. Fill out the top of the form prior to commencing the census. The Beaufort wind code and sky condition codes are given in the instructions for the Breeding Bird Survey of North America in this Technical Note.

2. Record all birds either heard or seen on the form in the appropriate column, depending on the perpendicular distance of the bird from the central line of the transect. Birds may be tallied or marked in the appropriate column by the use of dots or other marks, by species.

3. Walk slowly along the central transect line, noting all birds detected until reaching the end of the transect. If possible, carry an aerial photograph and plot the exact location for each bird observed. Special landmarks or different characteristics of the vegetation visible on the photograph make the bird mapping easier. Measure actual distances to the observed birds later from the aerial photograph, if desired.

4. After completing the transect route, determine how many birds were detected in each of the different parallel strips. Determine the strip that contained the basal plateau and then compute a projected number of birds for the entire transect width. Calculations are in this section and illustrated in Fig. 13.

(9) Population Estimates. Determine estimations of population density for species observed on strip transects by one of three methods, depending on the conspicuousness of the species. The validity of any of these methods varies for different species. Professional judgment, based on past experience with the noticeability of various species within different habitats during different seasons, must be used in selecting the best density estimator. As an illustration of the procedures of density estimation utilized for strip transect data by the three methods discussed below, a sample problem is provided in Figure 13.

(a) For species which are associated with distinctive habitat types, are conspicuous, and occupy large activity areas, Method "A" usually provides the best density estimate. This method assumes that because of their conspicuousness and activity, all individuals occupying the strip transect area are tallied by the census taker. Thus, the method simply involves division of the total number of individuals seen on the transect by the total area of the transect to obtain estimates of number per hectare.

(b) Method "B" recognizes that most species become less and less conspicuous over distance and therefore have a decreasing probability of being recorded with increasing distance from the transect route. Thus, a coefficient of detectability (C.D.), the proportion of a species' population which is ordinarily detected by an observer is used to adjust the estimate obtained by Method "A." The coefficient of detectability is determined directly from data on the distribution of detection points perperdicular to the transect route. The transect route bisects the sampling area, which is divided into a series of strips parallel to the central route. Assume that all individuals of a species observed in strips preceding and including the strip containing the greatest number of birds for that species represent the total number of birds present within those strips. This sum, termed the basal plateau level, is extrapolated to the limits of the entire census band (244 m) so that the resulting figure represents the projected number of birds for a species within the entire transect. The coefficient of detectability for the species is then determined by dividing the observed number of birds within the transect by the projected number. The C.D. thus represents the efficiency of the census for a particular species. Dividing the density estimates obtained in method "A.1.a." by the C.D. proves an adjusted population density estimate. Figure 14 illustrates the kind of intuitive process which occurs in determining a C.D. Since the conspicuousness of a species varies between different habitats and in different seasons, a C.D. must be calculated for each species on each transect.

(c) When the assumption of complete censusing of birds of a species close to the transect route cannot be met, such as in instances of particularly shy or retiring species, method "A.1.c." is employed for density estimation. This method involves multiplying the estimate obtained in method "A.1.b." by an additional adjustment factor, the basal detectability adjustment, which adjusts for those species

Fig. 13. Data Analysis - Strip Censuses

Sample Problem for Density Calculations
Using Strip Transect Data

Species: *Brewer's sparrow* Dates: *June 15, 19 6*

Site: *Transect X* Comments: *"Hypothetical Data"*

Project: *Piceance Basin Oil Shale Project*

Count Results Summarized:

Individuals Observed

Date	0-10'	10-25'	25-50'	50-100'	100-200'	200-400'	
June 15	*2*	*3*	*5*	*1*	*2*	*0*	*13*
Σ 1/	2	3	5	1	2	0	13

Baaal Plateau Level: *10* Projected Census: *80* Strip Width: *0.244 km*

Total length of census strip (km): *0.8 km* C.D. = $\frac{\text{Observed}}{\text{Projected}}$ = *0.162*

Census Estimate:

A. Unadjuated: Strip Width *(0.244 km)* X Strip Length *(0.8 km)* = 0.195 km^2

Number observed *(13)* ÷ *0.195* km^2 = *67* indiv/km^2

B. Adjuated for C.D.: $\frac{\Sigma \text{ Observed}/0.195 \text{ km}^2}{\text{C.D.}}$ = *412* indiv/km^2

C. Adjusted for C.D. and Baaal Detectability: B.D. Adjustment = *1.5*

Revised cenaua: B.D. X Census Estimate B = *618* indiv/km^2

1/ Σ means summation or total

INSTRUCTIONS

1. Fill out the top portion of the form as shown in the example.

2. Count total number of birds detected in each strip from Fig. 13 (Field Data Sheet - Strip Census) and put the numbers in the appropriate columns on this form.

3. The basal plateau level in this example is 10 (2 + 3 + 5). The projected number of birds within this transect is 80, assuming that the birds in the homogeneous environment are fairly randomly distributed. Assume that all birds in each successively distant strip are detected so long as the number of birds detected in each successive strip is increasing. The strip distance at which the number of birds detected drops off is known as the basal plateau. From this point on, assume that some birds are undetected. In this example assume that if all birds are observed out to the 50-foot-distance (10), then there are a total of 40 birds out to the 400-foot-strip on each side of the center line of the transect, for a total of 80 birds.

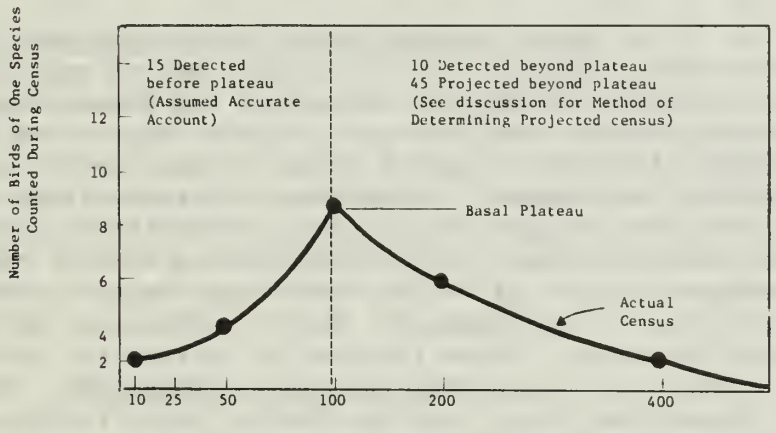
4. Determine the coefficient of detectability. The total number of birds detected for the entire 800-foot-wide transect in this example is 13. Total number of birds projected to be in the transect is 80. The coefficient of detectability (C.D.) for this species is determined by dividing the number of detected birds by the projected number of birds, 13/80 or 0.162.

5. The census estimates for items A and B (unadjusted and adjusted for C.D.), respectively, are self-explanatory, derived from the data provided in the example.

6. The estimate for adjusted C.D. and basal detectability (item C) cannot be computed unless the observer has access to, or has computed from his own experience a basal detectability factor for the particular species. This method adjusts for those species whose conspicuousness diminishes rapidly past some critical distance from the transect route. These birds may not be seen unless they flush nearly underfoot. Emlen suggests that the basal detectability adjustment should rarely exceed 1.6 for breeding bird populations because of the inactivity of the females and intermittent singing of the males. For those species warranting this correction, values of 1.2 and 1.5 may be applied for wintering and breeding birds, respectively, and should be fairly close if no other values are available.

Fig. 14. Example of Hypothetical Strip Transect Results to Show Method of Calculating Coefficient of Detectability (C.D.) Used in Formulas Presented in Fig. 13.

(Different figures are used here than in Fig. 13. for computing a species C.D.)



Birds Observed = 25

Birds Projected = 60

C.D. = 25/60 = 0.4

whose conspicuousness diminishes rapidly past some critical distance from the transect route; these birds may not be seen unless they flush nearly underfoot. Emlen suggests that the basal detectability adjustment should rarely exceed 1.5 for breeding bird populations because of the inactivity of the females and the intermittent singing of the males. For those species warranting this correction, values of 1.2 and 1.5 were applied for wintering and breeding birds, respectively.

(d) Dominant bird species of each vegetation type are identified by values of relative density derived from strip census densities. Percent relative density (% RA) is determined by the formula:

$$\% \text{ Relative Abundance (RA)} = \frac{\text{Density of a given species}}{\text{Density of all species}} \times 100$$

(e) Since the projected number per hectare takes into account correction factors applied to the observed population count, in the case of strip transect data, %RA is based on number per hectare, rather than actual number observed.

(10) Emlen Transect Method Advantages and Disadvantages: Both the International Bird Plot Census Method and the Emlen Variable Strip Transect Method have advantages and disadvantages. With the variable strip method, one person can sample large areas easily. Only three replications may be needed, whereas eight to ten are recommended for the spot map method. Variations in detectability among species are taken into account to a certain extent in the Emlen Transect Method. Once C.D. values have been established, a similar habitat can be quickly censused. Also, all birds, both breeding and nonbreeding (including fledglings), are censused. However, there are problems with the variable strip method. Males involved in territorial advertisement become less conspicuous as the breeding season progresses. Males of some species become less vocal once the females begin incubating or the young hatch. It is difficult to distinguish such a nonsinging territorial male from any other male who may wander through the area.

Conspicuousness of females also declines beginning with incubation. Shyness of some species makes it extremely difficult to detect them even at close range. These factors may make it difficult to arrive at a reliable C.D. and may substantially affect the overall population estimate. Calculating densities is another problem. The C.D. depends upon the distance of each bird from the transect line and the absolute detectability of the bird. It is assumed that all birds were detected within the strips on either side of the transect line out to a certain point (the strip where observations drop off sharply). In an area with fairly dense vegetation, this assumption may not be valid. If not, the total density value will be less than the actual number, which may account for the lower densities estimated using the variable strip transect method versus the spot map method.

(11) Observer Skills Required. Emlen noted several other problems with the variable strip transect method; both visual and aural identifications must be made. Identification skill of the observer, observation conditions such as weather, and misjudgment of the distance to birds are further sources of error. Also, with only three trips throughout the study area, a low density species may be missed entirely.

(12) Additional Factors in Selecting a Method. Consider the following additional factors when selecting a method for bird inventories. In the International Bird Plot Census Method, one advantage is that if territorial males are accurately counted, the number of breeding birds can be reasonably predicted, but this is not easily done. In interpreting spot maps, it is useful to know bird territory size; however, for many birds, territory size is not known. It varies with many circumstances such as habitat, breeding bird density, and individual differences in aggressiveness. During years of high densities, territories may be compressed and territorial males more vocal, thus increasing their detectability. Also, many singing males may be unmated and do not represent mated pairs. The spot map method does not consider variation in adults or territories during the raising of second broods. Also, toward the end of the breeding season, territories begin to break down and accuracy of spot mapping declines rapidly. Both the spot mapping and strip transect techniques are useful in obtaining quantitative baseline data which will provide information for future comparisons. However, to be useful for such comparative applications, both methods are restricted to relatively homogeneous blocks of habitat. Species which prefer mixed or "edge" habitats, or other specialized habitats, must be inventoried separately, usually by qualitative observations. The total spectrum of birds in an area are thus inventoried and considered in land use planning.

c. Other Belt and Line Transects.

In a publication by the U.S. Fish and Wildlife Service dated September 1980 (FWS/OBS - 80/58) by Sharon A. Mikol and titled Field Guidelines for Using Transects to Sample Nongame Bird Populations, the author discusses belt and line transect methods, key assumptions, and advantages and disadvantages in the use of transect sampling methods. Considerations in using belt and line transects are well explained, and anyone contemplating using these methods should review this publication. Emlen's transect methods are included. Some of the guidelines for transect sampling discussed by Mikol (1980) are presented below.

The basic types of transects discussed are the belt transect and the line transect, as depicted in Figure 14A. Two of the transect methods rated as acceptable are those dscribed by Emlen (1971) (without the coefficient of detectability) and Balph et al. (1977).

With these methods, the observer records the right angle distance for each bird, either by estimating the distance or by recording the location of the bird by distance intervals of predetermined width. Frequency histograms of the right angle distances (from the transect

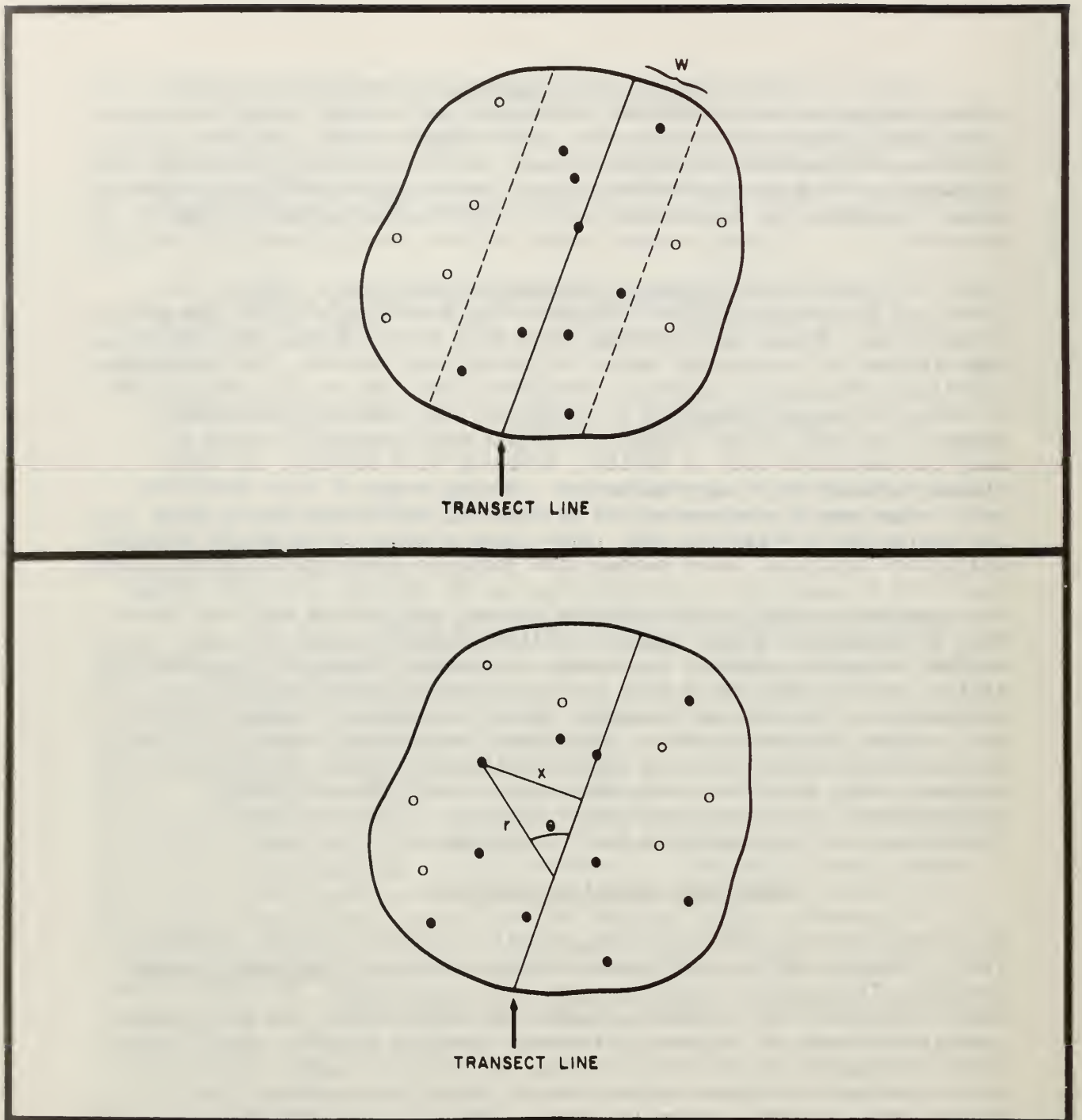


Fig. 14A. Diagram of belt transect (top) and line transect (bottom). In belt transect sampling, all birds are assumed to be detected (• = detected) within a specified, fixed distance (w) from the transect line of length L. Birds outside the belt are not recorded (o = undetected). Bird density = n/2Lw, where n is the number of birds recorded. In line transect sampling, the observer records either the right angle distance (x), or both the flushing distance (r) and the sighting angle (0) for each bird detected (• = detected; o = undetected). Bird density is estimated mathematically using the distribution of distances (x or r). (Mikol 1980).

line) are prepared and the effective width of the transect determined either subjectively or by some objective criterion. With the Balph method, the effective width is the distance at which the maximum number of birds are recorded. In the Emlen method, the effective width of the transect is either the distance corresponding to the inflection point of the curve or, more subjectively, the distance at which the number of birds recorded starts to drop off noticeably. The histograms and calculations in Figure 14B (from Mikol 1980) illustrate these two methods.

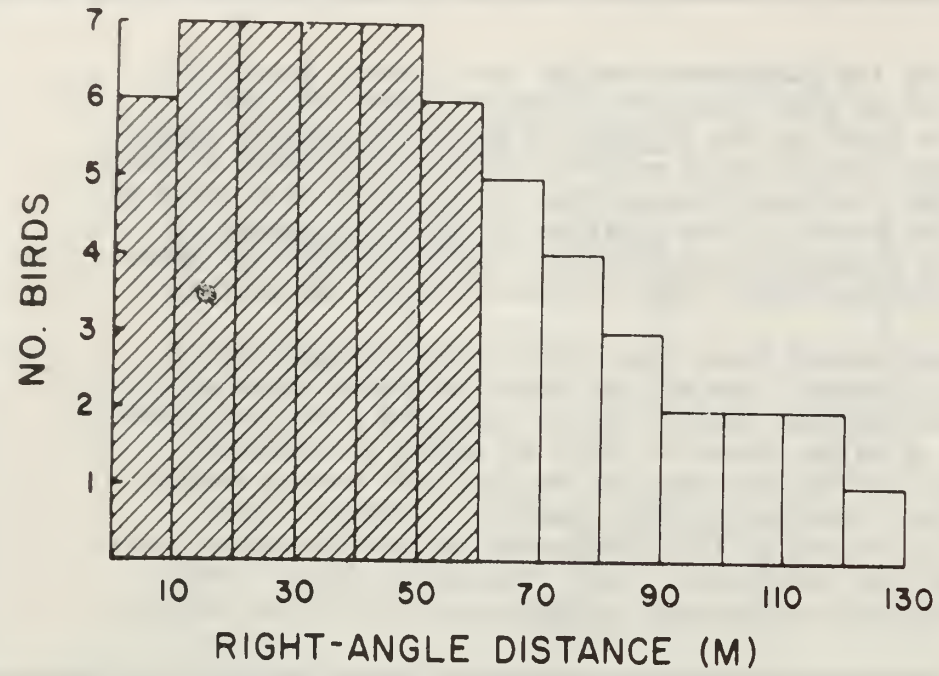
In a 1977 paper, Emlen stated that, even close to the transect line, some birds are missed because they are not emitting audible cues or are not in sight when the observer passes. Emlen suggested a way to calculate the proportion of birds missed in order to obtain a correction factor. Mikol et al. (1979) reported that Emlen's 1977 method consistently overestimated all species when she tested it. However, the correction factors calculated by them, according to Emlen's method, were not time specific as they should have been. Therefore, Emlen's 1977 method may have proven more acceptable if the proper correction factors had been used.

When using a belt transect, the researcher assumes that all birds within the selected width from either side of the transect line can be detected, either audibly or visually. Although this is probably true for narrow transects, detection of birds usually decreases with increasing distances from the transect line. This reduction in detection occurs because the songs or calls become less audible or the observer's ability to see or identify a bird decreases with increased distance (Mikol 1980). The transect belt width (w) should be selected as large as possible within the constraint that birds located at distance w will not be missed.

Some transect methods compensate for birds missed at increasing distances from the transect line (Mikol 1980). Frye (cited by Overton 1971) developed one of the earliest and simplest methods. His method requires recording right angle distances from each bird detected to the transect line and calculation of the mean of these distances. The density estimate is calculated from the number of birds within the mean right angle distance. For example, assume that you record 30 birds (n = 30) on a transect line 1,000 m (L = 1,000 m) long. The mean distance of the birds from the transect line is 50 m (w = 50 m). If 20 of the 30 birds (n_w = 20) you recorded were within the mean distance of 50 m, the density estimate would be:

$$D = \frac{n_w}{2w_L} = \frac{20 \text{ birds}}{2(50 \text{ m})(1{,}000 \text{ m})} = 20 \text{ birds per } 100{,}000 \text{ m}^2 \text{ or } 20 \text{ birds/10 ha.}$$

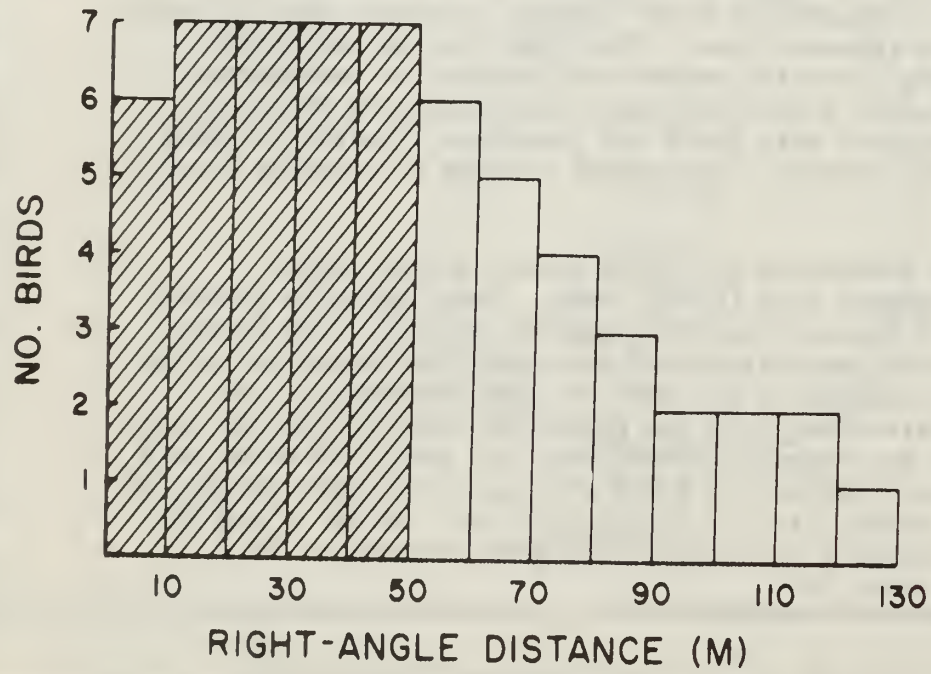
Several basic assumptions must be met in order to obtain a reliable estimate of bird densities from line transect studies. The following list of assumptions is from Mikol (1980) and is based on Seber (1973:20):



EMLEN (1971)

$$\hat{D} = \frac{40 \text{ BIRDS}}{2 \times 60\text{M} \times 1000\text{M}}$$

$$= \frac{133 \text{ BIRDS}}{40 \text{ HA}}$$



BALPH ET AL. (1977)

$$\hat{D} = \frac{34 \text{ BIRDS}}{2 \times 50\text{M} \times 1000\text{M}}$$

$$= \frac{136 \text{ BIRDS}}{40 \text{ HA}}$$

Fig. 14B. Examples of the use of frequency histograms to estimate bird densities according to methods developed by Balph et al. (1977) and Emlen (1971), from Mikol (1980).

(1) The birds must be randomly and independently distributed throughout the population area; that is, the probability of a given animal being in a particular area δ A is δ A/z. Eberhardt (1978), however, states that this assumption does not need to be met with random sampling but does need to be met with systematic sampling.

(2) The sighting of one bird must be independent of the sighting of any other bird.

(3) Each bird must be counted only once.

Seber suggests testing these first three assumptions by dividing the transect length (L) into a series of smaller segments of lengths (l) and determining the number of birds seen in each segment (nl). If assumptions 1, 2, and 3 are met, nl will have a Poisson distribution.

(4) If a bird is flushed, it must be recorded at the exact position it was when startled. This assumption cannot always be met, since birds, especially near the transect line, may move away from the approaching observer before being detected. This problem can be minimized when the observer concentrates on the transect line ahead of where he is walking.

(5) The behavior of the bird populations being sampled must not change significantly during the course of running the transect.

(6) The birds, regardless of sex, age, or other differences, are homogeneous in their response behavior during the course of running the transect. If a bird population is not homogeneous in terms of response behavior, it must be subdivided into subunits that are homogeneous.

Recent work by Burnham et al. (1979, 1980) indicates that some estimators exist that do not require that assumptions 5 and 6 be met. These estimators are pooling robust; that is, these estimators are not biased by pooling data over variables such as species, sex, age, or the time of day transects are run. Pooling robustness only occurs when differences in detection probability between different strata, such as species, age groups, or sex, are not extreme. With a pooling robust estimator, bird species with small sample sizes (n = 5 to 10) can be combined with other species to obtain a more desirable sample size ($n \geq 40$). However, it is only advisable to combine species with similar detectability curves, such as pileated woodpeckers and common flickers or yellow-rumped

warblers and chipping sparrows. In some population estimation studies, objectives may be such that densities of species need to be kept separate, regardless of how small the sample sizes are (Mikol 1980).

(7) The probability of seeing a bird on the line transect path must be one (1). The probability of seeing a bird, given that it is at right angle distance y from the line transect path (regardless of which side of the path the bird is on), is a simple function g(y), such that g(0) = 1.

Some of the advantages and disadvantages of transect methods discussed by Mikol (1980) are presented below:

(1) Advantages of Transect Methods (Mikol 1980)

(a) Belt or line transects can be used at any time of the year and results for different seasons or months compared. Spot mapping can only be done during the breeding season.

(b) Each run of a transect on each transect line can be considered a sample replicate. In addition, if the line transect estimators discussed by Burnham et al. (1980) are used, sampling variances for the density estimates can be calculated.

(c) Belt and line transect sampling methods are, in general, less time consuming and easier to do than other methods of collecting data for population density estimates (Emlen 1971).

(2) Disadvantages of Transect Methods (Mikol 1980)

(a) The observer must be able to estimate all distances correctly (at least by distance intervals) for line transects or the data will not meet the requirements for data analysis. For belt transects, distance estimates must be correct only at the outer boundary of the belt.

(b) It is difficult to determine the correct width of the belt in belt transect sampling. A wide belt may result in incomplete sampling for some species if there is a decrease in species detectability with distance. A narrow belt may also miss some species, especially those with large home ranges (Mikol et al. 1979). A narrow belt also has a very large edge relative to its area, which

may result in a high variability of population estimates due to birds moving into and out of the belt.

(c) The distribution of right angle distances with line transects or, equivalently, the effective width, will often be different for different species. Even so, the observer may have to subjectively pool data for different species together to obtain sufficient data to calculate the population parameters needed (desirable sample size at least 40).

(d) Some birds may be missed even though they are close to the transect center line. Emlen (1977:457) suggests calculating the frequency of cue production ("...the proportion of observer encounters in which birds make their presence known by emitting detectable cues") and using the inverse to correct for missed birds. Using this correction factor, however, will add additional sampling variation to a density estimate.

(e) An inaccurate estimate of population density may be obtained if the frequency histogram of right angle distances for the data collected does not fit the distribution pattern required for the sampling method used. Some of the more recently developed data analysis methods do not require the data fit any particular distribution in order to obtain reliable results from line transect sampling (Burnham et al. 1980).

A few additional things to remember in belt and line transect sampling include:

(1) Check your distance estimates frequently to be sure you are reasonably close in your estimates. Distances look differently in different kinds of habitat, e.g., sagebrush v. juniper.

(2) If the observer veers towards the birds he is trying to detect, he will bias the count.

(3) The observer should not stop near alarmed birds, since they will tend to attract other birds, thus biasing the density estimate.

(4) Avoid noisy or colorful clothing that may affect bird behavior, biasing the count.

d. Walking Census Route. A simple method for determining bird species occurrence and relative density is the walking census which consists of a transect in the shape of a square or rectangle. Procedures for conducting this type of transect route are:

(1) Select the habitat sites to be sampled. By definition the habitat sites should contain fairly homogeneous vegetation in approximately the same seral stage.

(2) Plot the largest square or rectangle that can be fitted into the habitat site and still remain at least 1/4 mi (or about 400 yd) from the boundaries of adjacent habitat sites. The observer should be far enough into the vegetation type to reduce the chance of observing birds of the edges, or ecotones, between vegetation types. The square or rectangle should have a perimeter of approximately five miles and may be varied or made into an odd-shaped polygon to conform to the shape of the habitat site.

(3) Establish a separate transect line to determine bird species that predominantly use the edges or ecotones.

(4) Walk the perimeter of the rectangle (or square), noting all species of birds either seen or heard. Other wildlife signs, such as bird nests, burrows, big game droppings, etc., should also be recorded. Since the primary results are species occurrence and relative abundance, all birds seen or heard must be tabulated. Based on a simple proportion of total birds of each species compared to the total number of all birds of all species observed, relative abundance will be calculated.

(5) Commence walking the transect approximately at sunrise and end observations within approximately four hours, since bird activity greatly decreases by 9:00 to 10:00 a.m.

(6) Survey for four seasons. If time and funds are not available for four season surveys, then a minimum of spring (nesting season) and winter surveys should be conducted. Intensity may be increased or decreased depending on accuracy of information needed and time and funds available. As a minimum, at least three runs around each rectangle should be made during the breeding season and three runs during different periods of the winter.

e. Cooperative Breeding Bird Survey of North America (Roadside Counts). The cooperative breeding bird survey was set up by the U.S. Fish and Wildlife Service to be conducted throughout North America annually and provides information on distribution and relative abundance of North American birds. It specifically measures abundance changes resulting from changes in land use and widespread applications of pesticides and is basically a roadside count. It may be used anywhere during the breeding season to determine relative bird populations and composition. When this system is used to collect district bird

information, conduct it in the standard manner prescribed below so that the information may be submitted and used as part of the annual North American bird survey.

(1) Sampling Technique

(a) Conduct the census along the same route for results to be comparable from one year to the next. The nesting phenology and weather should be approximately the same. The route should be started exactly 1/2 hour before sunrise. Make 50 stops 1/2 mile apart and count all birds heard at each stop or seen within 1/4 mile (400 m) during a three-minute watching and listening period. One observer must do all the observing on a given route, but an assistant may help with recording or driving. Unless driving conditions are very poor, most routes should be completed in 4 to 4-1/2 hours.

(b) Run routes in most states in June. In California, Nevada, Arizona, New Mexico, and Texas, routes may be run as early as May, depending on the peak of the breeding season. Where the route is run for more than one year, select a date as close as possible to the previous year's census.

(c) Scout the routes. Leisurely trial runs may be made in advance to become familiar with songs and calls and with roads and stopping locations. A single route may be run more than once if the observer wishes to have the practice, but only one route coverage should be accepted (or reported to the U.S. Fish and Wildlife Service, if this is desired). The accepted count must not be the best of several coverages, but the first one made under satisfactory conditions of weather and familiarity with birds along the route.

(2) Directions for Running Routes.

(a) Equipment. Carry a clipboard, pencils, map, binoculars, watch with second hand (or automatic three-minute timer), and thermometer. If data is to be included in the Cooperative North American Breeding Bird Survey for the year, obtain the appropriate forms from the Migratory Bird and Habitat Research Laboratory, U.S. Fish and Wildlife Service, Laurel, MD 20811. Complete all of the data items on the form. Even for strictly district use, complete the same data items for comparison with past or future years.

(b) Weather. To be comparable, routes must be run under satisfactory weather conditions, good visibility, little or no precipitation, and light winds. Occasional light drizzle or a very brief shower may not affect bird activity, but avoid fog, steady drizzle, or prolonged rain. Except in those states where winds normally exceed Beaufort 3 (see A.1.c.[2][c]), counts preferably should be made on mornings when the wind is less than 8 mph and not taken if the wind exceeds 12 mph. If it is possible to walk faster than the wind is blowing, winds are very satisfactory.

(c) Wind Speed Codes.

Beaufort number	Wind speed mph	Wind speed indicators
0	<1	Smoke rises vertically.
1	1 to 3	Wind direction shown by smoke drift.
2	4 to 7	Wind felt on faces; leaves rustle.
3	8 to 12	Leaves, small twigs in constant motion; light flag extended.
4	13 to 18	Raises dust and loose paper; small branches are moved.
5	19 to 24	Small trees in leaf sway; crested wavelets on inland waters.

(d) Sky Condition Codes (Weather Bureau Code Numbers)

0 Clear or a few clouds (up to 10% cloud cover)
1 Partly cloudy (scattered) or variable sky (10% to 50% cloud cover)
2 Cloudy (broken) or overcast (50% to 90% cloud cover)
4 Fog, dust, smoke (visual obscuration)
5 Drizzle or rain
7 Snow
8 Showers

(e) Starting Point. Be at the starting position (the first counting station or stop no. 1) at least two minutes before official starting time to record weather and speedometer reading.

(f) Observations. Look and listen for exactly three minutes and record the number of birds of each species seen within 1/4 mile (400 m) in all directions and all birds of each species heard regardless of distance. Try not to duplicate birds that appear to be more than half the distance to the next stop.

(g) Drive 0.5 Mile to the Next Stop. If the route map has marked stops or descriptions of stops, use these and ignore the speedometer except where the exact location is vague. If this stop falls in a place where it is dangerous to stop or where local noise is excessive, the stop may be moved as much as 0.1 mile (forward or back). Do not record any bird seen or heard while driving between stops unless it is subsequently heard at the next stop during the prescribed three-minute period. In case of excessive traffic noise, up to one additional minute (but no more) may be added to a few stops, but not routinely to all stops. Complete the 50 stops on schedule because singing decreases appreciably soon after 9 a.m.

(h) Mark Stations on Map. Mark all stops as accurately as possible on a permanent map so that other observers in subsequent years will be able to stop in the same spots. Convenient landmarks will help in plotting the stops on the map.

(i) Make 50 Stops. Each census route consists of exactly 50 stops (24 1/2 miles). Allowing three minutes for each stop and two minutes driving time between stops, approximately 12 stops will be covered per hour. The entire route will take a little over four hours.

(j) What Birds to Count. Count individuals of all species (including rock doves) seen or heard that can be identified. Any bird known to be a nonbreeder (late migrant, injured bird, or summer vagrant) should be included but noted as such. Estimate numbers only in those cases where a flock is too large to count, bird by bird, in the brief time it is seen. No one will detect all birds within hearing or seeing distance of his stops. Observers should not try to estimate birds that are missed or to include them on their report forms even if they are known to be present. Record only those birds actually seen or heard during the prescribed three-minute stops. Be careful not to count any bird(s) known or strongly suspected to have been counted at the previous stop. Any unusual species in the area should be verified by including some details or descriptions in the observation. Record birds seen in flight the same as birds perched, feeding, etc. Conduct breeding censuses at suitable times to sample the early and late breeding bird populations. If time, personnel, and finances permit, three to five censuses are desirable. Conduct two winter population censuses in January with an interval of two weeks separating each census. Figure 15 is a sample form that may be used for both the roadside counts and riparian censuses. Use one sheet for each 20 consecutive stops, for a total of 50 stations.

f. Riparian Bird Censuses. Many riparian bird species are unique to their habitat and can only exist where that vegetation is maintained. Despite the fact that riparian vegetation represents an extremely small portion of habitat on public lands, it supports as many as five to six times the number of bird species and three times the number of individual birds supported per acre in other more extensive habitats. Baseline data on current riparian bird populations are urgently needed. Presently there are no means to measure changes in those populations where industrial and energy developments, water developments, pesticide spraying, recreational developments, livestock grazing, and other land management activities may modify that habitat. Streamside brush and tree communities on most public lands throughout the West are narrowly constricted and very irregular in shape. The line transect census described here will provide essentially the same type of data as does the roadside transect census (Cooperative Breeding Bird Survey of North America).

(1) Sampling Procedure. Each riparian line transect consists of 20 stops permanently located at intervals of 100 m. This is a walking transect where all birds seen or heard within 50 m of the station during a five-minute observation and listening period are recorded. Each transect may follow an irregular meander line depending on the extent and density of the vegetation and the nature of the river or stream channel. Use the same form used in the roadside survey (Figure 15) in recording the riparian census data. The location and

Fig.15. Field Data Sheet - Avian Road Count
(Can be used for nocturnal bird counts)

Project_____ Observer_____
Count Location_____ Time Start_____ Time Finish_____
Date _____ Temp Start_____ Temp Finish_____
Sky Condition_____ Wind Start_____ Wind Finish_____
(Beaufort Scale) Precipitation_____
Route Number and/or Deacription:

Species	Roadside or Riparian Census Station Number																				Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
St ne	3	1		4		5	1	2		4	6	1	3	5	2	8	7	1		4	57
Sp br	4	1	1	3	5		2	2	2				7		4						31
Er al							2						4			1					7

INSTRUCTIONS

1. This form may be used for roadside counts (North American Breeding Bird Survey Method), for riparian census, and for nocturnal bird counts. Three forms are required for the roadside count method (50 stations), while only one form is necessary for a riparian census if only 20 stations are used.

2. The roadside count consists of 50 3-minute stops. All birds seen or heard within 400 meters (1/4 mile) of the station are recorded, by species. Begin censusing by local sunrise and complete within 3.5 to 4 hours after sunrise. The transect is generally run by automobile and the stations are at 0.5 mi. (0.8 km) intervals.

3. The riparian census consists of a transect line containing 20 stops that are permanently located at intervals of 100 meters. It is a walking census. Record all birds seen or heard within 50 meters of the station during each 5-minute observation and listening period on the form, by species. Each transect may follow an irregular meander line depending on the extent and density of the vegetation and the nature of the river or stream channel.

4. For nocturnal bird censuses, drive roads at night and stop approximately every one-fourth mile to play recorded calls of any species for which the census is desired. Many nocturnal species that are shy and retiring by day, can be detected from their responses to tape-recorded calls at night. Distance between stations and listening time for responses must be varied according to the particular behavioral habits of the species being censused. The best methods to use for any species for a particular region of the country is determined primarily from personal experience.

number of these line transects vary depending on the number and variety of river and stream areas and the same general constraints specified for the roadside censuses apply.

2. Terrestrial Colonial Species.

a. Surveys for passerines or other terrestrial birds that tend to colonize cannot be conducted in a random fashion within specific vegetation or habitat types; they must be conducted on either a specific species basis or on the basis of surveying unique habitat features that one or more species normally occupy. For example, if biologists wish to survey for cliff swallows, they must systematically search for and examine all geologic features and manmade structures on which the swallows have been reported to nest, e.g., rocky or hard clay cliffs, bridges, trestles, old houses and other buildings, highway overpasses, etc. Figure 16 is a form that may be used for recording occurrence of colonial terrestrial species or colonial water birds.

b. Cliff swallows, swifts, barn swallows, bank swallows, etc., are normally quite conspicuous because of relatively high numbers in fairly restricted areas. Whenever flocks of known colonial birds are observed during the breeding season, assume that their nesting area is close by. Watch the birds until a few are observed going to their specific nesting area.

c. The same type of habitat, such as cliff or bridge, is frequently attractive as a nest site for several species. Barn swallows and cliff swallows very frequently nest under the same bridge, often within a few feet of each other. Bank swallows and rough-winged swallows may nest in the same clay bank. Violet-green swallows and white-throated swifts frequently nest in adjacent crevices or holes high on cliff faces.

d. Knowledge of specific species nesting (or other) habitat requirements is essential before attempting any surveys for colonial species. For example, barn and cliff swallows do not use highway overpasses or otherwise suitable cliffs for nesting unless there is suitable mud nearby for nest building. In addition, swallows and other species that feed mostly on aerial insects prefer to nest in locations that are reasonably close to aquatic areas that supply mosquitoes and other insects for feeding themselves and their young.

3. Nocturnal Birds.

a. The census of nocturnal birds presents a special problem because the birds cannot be visually counted. Owls, nighthawks, poorwills, etc., are normally hidden during the day and may feed mostly, or entirely, during the hours of darkness.

b. The most common method used to census nocturnal birds is to obtain taped recordings of their calls and to play these calls back during appropriate hours of the night. During the nesting season, most owls respond to taped calls of their own species. Recorded calls

Fig. 16. Colonial Nesting Survey Report

Example and Instructions

Species: *Cliff Swallow*

Location of Colony: Range *88W* Township *15N*

Section *13* Quarter Section *NE*

Location of Nests: *Underneath overhang of rock outcrop*

Vegetation Type: *37* Special Habitat Feature Code(s): *A-10, A-05*

No. of nests or nesting pairs: *28* Standard Land Form *BTT*

No. of young fledged or about to fledge: *0*

General Comments: *100 yards from East Fork Savery Cr. on north side of stream*

Observer's Name and address: *Henry Woodside*
5 Sawdust Lane
Baggs, Wyo. 82321

Date: *June 10, 1977*

INSTRUCTIONS:

Location of Nests: Clearly state where nests are located. They may be in trees, in cattails or bulrushes, on the bare ground, etc.

Vegetation Type: See Kuchler's list or BLM Manual Section 6602

Special Habitat Feature Code: See BLM Manual Section 6602

Standard Land Form: See BLM Manual Section 6602

Number of Nests: Where nests are in tunnels, use best estimate based on birds entering or leaving a tunnel or tunnels.

Where young are in the open, try to get an estimate of total young surviving to fly.

are available from the National Audubon Society, National Wildlife Federation, and other sources. This method is particularly helpful in detecting spotted owls, saw-whet owls, great horned owls, and several other owl species. Some experimenting is required to determine the usefulness of these taped calls for various species, depending on weather conditions, terrain, species response, and other factors. Owl responses are generally an indication of territoriality and a nearby nest. Road censuses for owls may be made by driving on a road in suitable habitat and stopping approximately every 1/4 mile to play the recorded calls. Voice calls which imitate the particular species are also effective in eliciting responses. The birds that respond can then be spot mapped and assumed to be in their nesting territory. Follow a similar procedure for a variety of other nocturnal birds, varying distance and listening time according to the particular habits of the species being censused. Use the form shown in Figure 15.

4. Upland Game Birds.

a. Methods. A variety of methods may be used to determine species occurrence, relative abundance, or trends of upland game birds, and include roadside and call counts, using dogs to detect coveys, searching for leks (strutting grounds), strip transect methods (King strip census, etc.), and searching for presence and abundance of sign (tracks, droppings, dustings, etc.). A review of the applications and problems associated with each of these techniques is discussed in Wildlife Management Techniques (Giles, 1969). Biologists should select a method that will best fill their needs for information. Subsequent inventories should utilize the same method(s) and constraints for results to be reasonably comparable.

(1) Roadside Counts. The following is taken directly from Giles (1969):

> Roadside counts have long been a standard procedure for obtaining trend indices in upland game. In this method, country roads are traveled for the specific purpose of counting the numbers of individuals of the species being censused which are then related to the number of miles traveled. Thus, in the case of rabbits, if a 20-mile census-route was driven, and 10 rabbits seen, the census-index would be given as 0.5 rabbits per mile. Roadside censuses are used widely in the midwestern states to census both rabbits and pheasants. Some states secure the cooperation of rural mail carriers to obtain estimates of the abundance of their principal game species (Greeley et al. 1962).
>
> The advantages of this method are obvious. Large areas are quickly and easily traversed in the comfort of an automobile. Unfortunately, the factors affecting the roadside census are so many and important (Newman, 1959) that investigators who ignore them are obtaining useless information. Factors other than abundance that determine the numbers of animals seen

during a census are: (1) activity of the animals as affected by hour of day, food supply, and weather, or (2) condition of roadside cover. Rabbits regulate their activity according to standard time, having an evening and an early morning peak of activity which is almost completely unrelated to sunrise or sunset (Lord, 1959). Pheasants, on the other hand, are regulated by the time of sunrise and have an early morning peak in their activity. There are likewise seasonal changes in the amount of activity by rabbits (and presumably other species) which has an important effect on the roadside-census results. In addition there are seasons when roadsides are used as cover by animals. During the winter in the midwestern states, pheasants, rabbits, and quail frequently take advantage of the vegetative cover associated with the roads in this intensively cultivated region.

Daily weather changes have an effect on animal activity which is not yet clearly known. It is apparent that periods of intense cold will inhibit the activity of animals. Also, rain or snowstorms interfere with the vision of the observer; therefore, investigators must avoid such unusual weather conditions. The condition of the roadside vegetative cover has an important effect on the visibility of game. The tall vegetation of late summer seriously impedes observations while the snow cover of late winter enhances them.

It would appear that the strong influence of so many factors on the roadside census would reduce its value. However, ways are available to circumvent most of these factors, although it should be mentioned that use of these ways increases the work required to perform the census. The confusing effects of seasonal changes in activity may readily be avoided by comparing only those censuses made during some given month. A census made in March should never be compared with one made in August because the change in activity may have a greater effect on the census results than the shift in the abundance of the animals. The effects of weather on the roadside-census results may be reduced by avoiding unusual weather conditions and by performing the total census over a period of many days during the month. The technique of calibration (as discussed in the section, "Statistical Properties of Indices") can also be employed to make indices more comparable and reduce the effect of environmental changes.

Dasmann and Taber (1956) present a detailed discussion of seasonal variation in habits and visibility of sex and age classes of black-tailed deer. Such information is very valuable in planning and interpreting index counts.

Howell (1951) combined features of several methods to develop a roadside estimate of considerable promise for birds. He determined the absolute number of birds in small areas and

compared these numbers with the number seen on a routine roadside trip through the area. He calculated a measure of conspicuousness of each species by determining the ratio of those seen on the roadside count to the absolute number along the road. For example, if he saw 3 robins along a road where he knew from territorial counts that there were 10 robins, then he calculated the index of conspicuousness as 0.3. If this number is interpreted as the estimated probability of observing a robin, then the general theorem can be applied in obtaining an estimate from a count of robins on another route. Thus, if 6 robins are counted, under similar conditions, the estimate would be

$$\hat{N} = 6/0.3 = 20$$

Hewitt (1967) reported a roadside count of redwing blackbirds in which he recorded the location of singing males. On a subsequent count he recorded the proportion of these males again seen, by which proportion he estimated the probability of observing a male on the second count. The resultant estimate,

$$\hat{N} = n/p$$

is identical in structure to a Lincoln Index. He extended the idea to several successive counts along the transect, obtaining a Schnabel estimate of N.

It is readily recognized that spotlight counts and horseback or foot counts of big game or upland game are closely related to roadside counts. Therefore, it is not unreasonable to treat them all (along with the King census method) as strip transects. The status of a particular count in the general category actually relates to the interpretive value, or inferential value, of the index. It is frequently a poor assumption that roadsides are typical (and hence representative) of the area in general, so that the index cannot usually be expanded to a population estimate. However, many exceptions to this will be found, as in much of the Florida deer country, or in the cut over Coast Range or Oregon.

The roadside count was a standard feature of the Southeastern Dove Study (Southeastern Assoc. 1957), both as uncontrolled counts (total tally of doves against total miles driven by biologists and game wardens) and as controlled counts during which specific routes were driven at specified times for the express purpose of counting doves.

(2) Call Counts or Auditory Indices (crowing counts, drumming counts, etc.). Auditory indices may be used for many species, including Gambel's quail, bobwhite quail, pheasants, mourning doves, ruffed grouse, blue grouse, woodcock, chukar partridge, and wild turkeys. Giles (1969) provides the following:

Counts of auditory signs of animal presence have a long history. Stoddard (1931) reported the use of counts of whistling cocks as a technique for measuring abundance of quail and a statewide standardized quail call index was started in Missouri in 1939 (Bennitt 1951). McClure (1939) described in detail a census method for mourning doves based on counts of calling doves and (1944 and 1945) a crowing cock census for pheasants. Kimball (1949) also reported a roadside pheasant crowing census. In 1951 standardized dove call count routes were established under the Southeastern Cooperative Dove Study (Southeastern Assoc. 1957). Drumming counts of ruffed grouse were reported by Petraborg et al. (1953) and Hungerford (1953). Auditory counts have also been reported for woodcock (Kozicky et al. 1954), Gambel quail (Smith and Gallizioli 1965), chukar partridge (Williams 1961) and other species as turkeys and squirrels.

Foote et al. (1958) described a randomized dove call count census featuring randomly selected routes within ecological strata of seven southeastern states. This design forms the basis for the current management routes (Wight and Baysinger 1963) and culminates several years of investigation of the call index (Southeastern Assoc. 1957). The standardized route consists of 20 stations at 1 mile intervals, with counts beginning 30 min. before sunrise. Calling doves are counted for 3 min. at each of the 20 stations with 3 min. allowed for travel between stations. Thus, the total elapsed time for the census is 2 hours, standardizing the "hour" effect. All counts are run between May 20 and June 10.

Approximately 650 comparable dove call routes are run annually in the 48 states and parts of Canada. Results of these indices are published in the Annual Mourning Dove Status Report, Bureau of Sport Fisheries and Wildlife.

It is generally recognized that auditory activity, like other animal activity, is influenced by time of day, weather conditions, season of the year, and a great many other factors which may or may not be apparent to the investigator. For example, McClure (1939) constructed correction factors for wind, cloud cover, temperature, and time of day in describing a call census for doves and later (1945) presented differences in pheasant crow count indices under variation in time of day, temperature and relative humidity. Bennitt (1951) reported an attempt to calibrate quail call indices for regional effects and for the effects of temperature. He advocated that counts be discontinued if wind rose above Beaufort 3.5 or if rain began, and presented evidence that type of road and cloudiness had no appreciable effect. Kozicky (1952) analyzed the effect

of several weather variables on pheasant crowing counts and found significant effects of wind and dew but none for temperature or cloud cover.

The influence of time of day is apparent from all studies and several methods have been proposed to adjust for it. Generally, the most popular solution has been to standardize the counts with respect to the period of the day during which the counts are made. Heath (1961) advocated uniform spacing of stations over the prescribed time even if the number of stations is somewhat smaller than the number accommodated by the allowed time. An alternative solution (equivalent to Heath's if the temporal function is linear) is to adjust each count to the equivalent count at, perhaps, sunrise.

A number of studies have been made of the variability of counts, with evaluation of the contribution of stations, days, observers, and hour of day, in addition to that of weather factors, to variance among observations (McGowen 1953, Carney and Petrides 1957, Kozicky 1952). Several studies have also been made of the behavorial aspects of calling. Cohen et al. (1960) reported statistical evidence that calling activity of individual doves is serially correlated--that calling activity is intermittent and not random. Frankel and Baskett (1961) and Jackson and Baskett (1964) showed that calling activity is related to the formation of the pair bond and to stages of the nesting cycle. Also, it is generally accepted that for several species calls are contagious, that the calling of one cock pheasant or one male bobwhite will stimulate another to call. Kimball (1949) recognized that this phenomenon in pheasants may cause the calling index t to increase disproportionately to N.

Underlying all of the studies of variability, effect of weather, and behavioral aspects of the auditory index is a general awareness that the index must be calibrated to account for these factors. Bennitt (1951) used linear regression to calibrate t with the hunting success of the following season. The relationship was significant but the value of R^2 too small to justify a very great expenditure of money in making the index. Norton et al. (1961) have since shown some errors in Bennitt's calculations, but the conclusions are unchanged. Rosene (1957) also used a linear regression technique to relate number of calling cocks to the number of coveys the following fall. His analysis was also shown by Norton et al. (1961) to be faulty, in that the predictive value of the index was not temporal. That is, Rosene's data do not show that the inex can be used to accurately predict temporal changes in the populations. However, they do show that the call index is a good estimator of the population level on an area; spatial predictability is good, so that one can infer that the call index reflects general population level.

Smith and Gallizioli (1965) take advantage of the lessons learned from reappraisal of Bennitt's and Rosene's data and present good evidence that the spring call index is a useful predictor of temporal variation in hunting success of Gambel quail in Arizona. They point out that the index appears to reflect both spring population level and breeding success, so that it is of greater management value than is a simple index to the spring population level.

The above studies relate to predictability of the fall population. The question of how well the call index relates to the level of the breeding population has been studied by Lowe (1956) and Dorney et al. (1958). In the latter study, for ruffed grouse, one area, 3 years, there was insufficient variability for a meaningful analysis (N = 25, 25, 30; t = 58, 71, 66; A = 0.43, 0.35, 0.45). Lowe's data, average density of pairs of doves for several areas on 3 years (N = 4, 2.0, 2.85; t = 2.60, 1.15, 2.28; A = 1.54, 1.74, 1.25), are a little more convincing.

The current status, then, of the auditory index is that it is a widely used management index for quail, doves, pheasants, and woodcock. In general, the index is standardized as to selection of route, starting and stopping time, number of stations per route and season of the year at which the index is determined. Some procedures attempt to adjust the index for effect of weather. Some are used as indices of spring population levels and others have been studied as predictors of fall populations or hunting success. With a few exceptions, it is judged that the potential value of this index has not been realized, that the call index is potentially much more valuable than one would infer from the general literature. Further development along the line of Heath (1961) will likely prove rewarding, as will additional development of calibration techniques.

(3) Using Dogs to Detect Coveys. Dogs may be used to assist in finding game birds, either by randomly locating them within a general area or by censusing along permanent transects (Overton, 1953). When using a transect, the perpendicular distance between point of bird location and the transect center line is recorded, as well as the number of birds in the covey. You may then calculate the average distance ($\bar{h}$), and the number of quail (t) found within this average distance and then estimate the total population as:

$$\hat{T} = \frac{CA}{2L\bar{h}}\, t$$

where again C = correction factor for units of measurement,
A = study area acreage,
and L = transect length.

Researchers have recognized that this formula underestimates the population, but it may be used as a trend indicator, as well as for a minimum estimate. For species occurrence alone, dogs may be worked across an area, with the biologists making note of the birds found. Dogs are also useful in locating duck nests. Several problems and precautions in the use of dogs for strip censuses are discussed in Giles (1969).

(4) Search for leks (strutting, booming grounds). Locating strutting grounds and conducting counts of either the males or all birds is a good method for estimating populations of sage grouse, sharp-tailed grouse, and prairie chickens. These species congregate on mating grounds in early to late spring, and their "booming" may be heard from as much as a mile away on quiet mornings. Total grouse estimates within an area are often made by locating all strutting grounds and counting all birds present at each ground on several consecutive mornings. The number present on any given lek will deviate on any given morning for a variety of reasons, so the highest count for all leks on any one morning is used for the estimate.

Leks may be found by using aircraft, by ground surveys, and using high altitude infrared aerial photographs. BLM Wildlife Biologist John Grensten found in Montana that sharp-tailed grouse leks show the same distinctive color, texture, and shape when viewed on infrared photographs. While dried-up natural potholes, salt licks, recently revegetated drill pads, portable corrals, or mud holes can be mistaken for leks, many such areas have proven to be active grouse leks. The traditional manner for locating strutting grounds is to drive roads and trails early in the mornings, frequently stopping to listen for distinctive sounds. Using aircraft for spotting the grouped birds is also frequently useful.

(5) Strip Transects. A strip transect is essentially a sample census where animals are recorded that fall within a specified area, usually within a given distance from the transect line. The King strip census is a typical example where appeal comes from its general simplicity. The observer walks along a "census line" (usually a blazed or marked trail or line that can be easily followed) and measures or estimates each animal's or group of animals' observed distances. Then the strip's "effective width" is calculated as some function of the observed distance. Principal variants involve differences in defining distance (from observer to the observation, e.g., the grouse, or perpendicularly from the observation to the transect line) and differences in calculating the effective width of strip from the measurements.

A simple application of the strip transect would be to decide beforehand how distant (perpendicularly) from the transect line observations would be included, e.g., 200 ft on each side, and then to calculate the total transect area based on this predetermined width (400 ft). The observer would then have an estimate of the number of animals within a specified area that (if representative of the entire area) could be applied to the

entire area for a rough estimate of the total population. The factors that may cause errors in the estimate, especially (1) difficulty in accurately estimating distances of observations from the transect line, and (2) the problem with animal secretiveness, or failure of an animal to flush or show itself as the observer approaches or passes, are discussed in the Emlen Transect Method. Such a transect, then, will usually provide a minimum estimate of game birds present.

B. Birds of Prey.

1. Data Requirements.

a. Need for Raptor Habitat Data. Data on raptor nesting habitat, feeding habitat (spring and summer), wintering habitat, roosting areas, etc., are essential to make appropriate land use decisions that will assure the perpetuation of all species of birds of prey. Birds of prey are at the top of their food chains; therefore, they are among the best animals for indicating environmental changes or pollution that may adversely affect the quality of man's environment. High national interest is centered on the birds of prey and special surveys and attention for these species are required of BLM managers to meet this public need.

b. Types of Raptor Habitat Data Needed by Land Managers. With this information land managers may modify or eliminate proposed or ongoing land use practices that may adversely affect raptor populations.

(1) Specific locations by species for raptor nesting, feeding, and roosting sites.

(2) Effects of man's activities on nesting or other life phases of raptors.

(3) General trends in raptor populations and productivity, by species, and the probable reasons for current trends.

(4) Specific area in size required by each species and by season of use. For example, how much timber should be left in a Goshawk nesting area?

2. Raptor Nesting Habitat Surveys.

a. Locations of Nesting Raptors. Many good bird guides are available that show the nesting distribution of the various raptors, such as the Audubon Society and Peterson guides. Be aware that certain raptors nest predominantly or entirely in certain parts of a state by virtue of topographic features, prey abundance, or other special features that meet some particular need for the bird's survival.

b. Preferred Raptor Nesting Habitat by Species. All raptors have a preferred or predominant nesting habitat that should be learned by the biologist prior to commencing surveys. BLM Technical Note No. 316 may be used as a guide.

c. Competition for Nesting Sites. Many species of birds of prey utilize nests constructed by other species. For example, great horned owls and long-eared owls commonly nest in Buteo and Accipiter nests. Long-eared owls, merlins, and even kestrels may utilize magpie nests. Red-tailed hawks, Swainson's hawks, and ferruginous hawks use each other's old nests or even golden eagle nests. Prairie falcons sometimes use old golden eagle and red-tailed hawk nests, etc. Because of this somewhat common interchange of nests, there is some competition for the nest sites between the various species. Normally, the first pair of birds that possesses an old nest will assert the necessary defense to maintain their ownership. Also, differences in nesting phenology may permit utilizing the same nest by two different species during the same year. Aggressive interactions between prairie falcons and great horned owls have caused great horned owls to abandon their nest sites with subsequent nesting at the sites by the intruding prairie falcons.

d. Territorial Requirements for Certain Raptors. General territorial requirements for selected birds of prey are presented in BLM Technical Note No. 316. However, territory sizes depend on many factors.

e. Procedures for Conducting Raptor Nesting Surveys and/or Nesting Habitat Evaluations.

(1) Locating and Examining Nesting Habitats.

(a) Map and Photo Studies.

i. Determine potential nesting sites (clumps of trees, cliffs, suitable ground vegetation, etc.) for the various species by examining appropriate maps and aerial photographs, which requires knowledge of raptor nesting requirements to make this evaluation.

ii. Plan aerial survey routes and/or ground access to the potential raptor nesting areas.

(b) Aerial Surveys.

i. Make flights over areas delineated in e.(1)(a)i. above and note on map locations all nests observed and suitable habitat that should be examined from the ground.

ii. Plan a flight to revisit the active nests at a time when the young will be in the nest. Nesting success can be fairly well determined on this flight.

iii. Obtain aerial photographs of the site for the raptor nesting file where special or unique topographic features are being used as raptor nesting sites.

(c) Ground Surveys.

i. Visit all nests and all potentially suitable nesting habitats, utilizing the best access routes observed from the air or shown on maps.

ii. Carefully examine all active nests and potential habitats until satisfied as to nesting species of raptors present. If this is done prior to egg hatching, use binoculars to obtain the desired information. After the young appear in the nest, there is less chance for nest abandonment and closer approaches may be made. Obtain photographs of the nesting site during this visit to include in the district biologist's field survey notebook. Map all old nests as these will frequently be used in subsequent years.

(d) Timing of Surveys.

i. Time of nesting surveys depends on the nesting chronology of the species for which information is desired. Time surveys to visit nests approximately one-half to three-fourths of the way through the nesting sequence. Avoid disturbing nesting birds, especially during early courtship, nest building, egg-laying, and incubating phases.

ii. Nesting sequences vary, either earlier or later, depending on latitude, seasonal variations in weather patterns, elevation, and other factors. (Technical Note No. 316 provides general information on raptor nesting chronology.)

(e) Precautions at Nest Sites.

i. Do not flush adult birds from the nests unless necessary to collect data on nesting phenology or reproductive success. If adult birds are flushed from the nest, try to limit the stay at the nest from 5 to 10 minutes, or less.

ii. Do not flush adult birds from the nest during rainstorms, in very cold, windy, or in hot weather. Absence of adults for longer than a (very) few minutes may cause the death of the embryos or young birds due to excessive cold or heat.

iii. Be sure adult birds and/or young birds are aware of your presence as you approach the nest. Do not startle incubating or brooding adult birds as they may spring from the nest, knocking young birds or eggs from the nest.

iv. Use care in approaching nests where young birds are old enough to fledge at your approach. In fledging prematurely, they may damage bones, incur other injuries, or become lost and/or abandoned.

v. Do not handle eggs or young birds unless necessary for banding, weighing, etc., as part of a data collecting project approved by the state wildlife agency.

vi. Exercise special precautions while surveying nesting eagles' habitats, since all eagles are fully protected under the Bald Eagle Protection Act.

(f) Nest Examinations: Dangers to Birds

i. There is always a potential for nest abandonment when a nest is visited during nest building, egg-laying, or incubating phases.

ii. Chilling or overheating eggs or young may occur if adults are kept away from the nest during cold, hot, windy, or stormy weather.

iii. Dehydrating eggs or an adverse change in humidity may occur if eggs are left unprotected.

iv. Young birds may miss essential feedings and become weakened.

v. When adults are forced from the nest, there is increased chance for predation of eggs or young by both aerial and ground predators.

vi. Premature fledging of young birds may occur with possible injury or parental abandonment.

(g) Special Precautions for Surveying Nesting Habitat of Endangered, Threatened, or Sensitive Species of Raptors.

i. Do not visit nests of species of raptors that have an endangered classification, unless accompanied by an authority on the species for a specific research or monitoring purpose.

ii. Use special caution in visiting nests of species known to be declining in numbers, either locally or nationally.

iii. Consider the locations of nests of endangered, threatened, or sensitive species of raptors as confidential agency information. Loss of nests or young from increased human visitation cannot be tolerated for endangered or declining species or for any species whose overall habitat is declining. Do not publicize nest locations of any endangered bird species, especially peregrine falcons.

(h) Specific Raptor Survey Methods and Nest Characteristics. Specific nest survey methods will not be discussed here as they have been addressed in BLM Technical Note No. 316. However, Figures 17 and 18 show the kinds of nesting information usually desired.

Fig. 17. Raptor Nest Data Form.

Observer _____ Nest Number _____

Date of Observation _____ Species _____

Land Ownership: P S BLM Location: T____ R____ Sec.____

Description of Nest Site:

Nest Substrate _____

Height of Substrate _____

Height of Nest Above Ground _____

Active _____ Inactive _____

No. of Eggs or Young _____

Exposure _____

Elevation _____

Vegetative Type _____

Remarks:

(Topographic Map)

(Photograph)

INSTRUCTIONS

1. Fill out this form each time a raptor nest is located. The general information is self-explanatory.

2. Xerox a portion of a topographic map that shows the particular area in which the nest is located and plot the nest location on this map segment. Secure the map onto this form.

3. Photograph each raptor nest located, whether active or not. Inactive nests one year may be active the next. A copy of the photograph(s) should be secured to the bottom of the form for future reference.

4. These forms should be retained by the biologist in a field inventory notebook (looseleaf) and should not be placed in central files. They are working field inventory notes not subject to public inspection. Give this field data to each successive biologist.

BLM STATE & DISTRICT NO.	AMS MAP NAME	NEST NO.	MO.-DAY-YR.	RECORDER'S NAME
METHOD OF SURVEY 1. FIXED WING AIRCRAFT-150 HP 2. FIXED WING AIRCRAFT-180 HP 3. HELICOPTER 4. FOOT 5. OTHER	LAT. LONG T._____ R._____ S._____ ¼ SEC._____ MILES TO HUMAN DISTURB._____ TYPE OF DISTURBANCE_____	OWNERSHIP OF NEST SITE 1. PRIVATE 2. BLM 3. FS 4. STATE 5. OTHER	MILEAGE OF NEST TO STREAM OR RIVER 1. ¼ MILE 2. ½ MILE 3. 3/4 4. 1 MILE 5. 1¼ MILES 6. 1½ MILES 7. 1 3/4 MILES 8. 2 MILES 9. OVER 2 MILES	NEST ELEVATION 1. 4500-5000 2. 5000-5500 3. 5500-6000 4. 6000-6500 5. 6500-7000 6. 7000-7500 7. 7500-8000 8. 8000-8500 9. 8500 FEET AND OVER
SPECIES 1. GOLDEN EAGLE 2. BALD EAGLE 3. TURKEY VULTURE 4. RED-TAILED HAWK 5. FERRUGINOUS HAWK 6. SWAINSON'S HAWK 7. AMER. ROUGH-LEGGED HAWK 8. MARSH HAWK	SPECIES 1. GOSHAWK 2. SHARP-SHINNED HAWK 3. COOPER'S HAWK 4. PRAIRIE FALCON 5. PEREGRINE FALCON 6. PIGEON HAWK 7. SPARROW HAWK 8. OSPREY	SPECIES 1. GREAT HORNED OWL 2. SHORT-EARED OWL 3. BURROWING OWL 4. BARN OWL 5. SCREECH OWL 6. LONG-EARED OWL 7. SAW-WHET OWL 8. PYGMY OWL 9. GREAT GRAY OWL 10. OTHER	GROUND NEST 1. TOP OF CLIFF 2. CLIFF SHELF OR LEDGE 3. CREVICE 4. OPEN HILLSIDE 5. LEVEL GROUND 6. HOLE IN GROUND	AZIMUTH READING GENERAL CLIFF EXPOSURE_____ ACTUAL NEST SITE EXPOSURE_____
TREE NEST 1. COTTONWOOD 2. ASPEN 3. SPRUCE 4. FIR 5. PINYON-PINE 6. BRISTLECONE PINE 7. OTHER PINE 8. JUNIPER 9. OTHER	TREE FORM 1. LIVE BUSHY TREE 2. LIVE SLENDER TREE 3. DEAD BUSHY TREE 4. DEAD SLENDER TREE TREE HEIGHT 1. TALLEST 2. TALLER THAN MAJORITY 3. SAME HEIGHT AS MAJORITY 4. SHORTER HEIGHT AS MAJORITY	POLE OR OTHER NEST 1. SINGLE POWER POLE 2. DOUBLE POWER POLE 3. TRANSFORMER 4. TELEPHONE POLE 5. BARN OR BUILDING 6. OTHER	HEIGHT, TREE OR CLIFF IN FEET 1. 0-25 FEET 2. 25-50 3. 50-75 4. 75-100 5. 100-150 6. 150-250 7. 250-400 8. 400 FEET AND OVER	NEST ABOVE GROUND IN FEET 1. 0-25 FEET 2. 25-50 3. 50-75 4. 75-100 5. 100-150 6. 150-200 7. 200 FEET AND OVER
NEST FRONTAGE 1. OPEN 2. RIVER 3. STREAM 4. LAKE 5. OTHER	NEST CONDITION 1. GOOD-NEW MATERIAL SEEN 2. FAIR-OLD MATERIAL ONLY 3. POOR-STABLE 4. POOR-UNSTABLE 5. REMNANT ONLY	ACTIVITY AT THE NEST 1. MATERIAL ADDED TO OLD NEST 2. NEW NEST UNDER CONSTRUCTION 3. NEST FOUND SINCE LAST SURVEY 4. ADULT WITH NEST MATERIAL 5. ADULT ON NEST 6. WHISTLING ADULT 7. ADULT ON NEST TREE 8. PAIR ON NEST TREE 9. PAIR ON THE NEST	EAGLES IN NEST TERRITORY 1. NONE OBSERVED 2. 1 ADULT AT OR NEAR NEST 3. PAIR AT OR NEAR NEST 4. 1 ADULT AND 1 IMMATURE 5. 1 ADULT AND 2 IMMATURES 6. 2 ADULT AND 1 IMMATURE 7. 2 ADULT AND 2 IMMATURES 8. 2 ADULT AND 3 IMMATURES 9. MORE THAN LISTED ABOVE	AGE OF YOUNG 1 EGGS 2 DOWNIES 3 PARTLY FEATHERED 4 NEST FLEDGING 5 FLYING YOUNG NO. OF YOUNG_____
MAJOR VEGETATIVE TYPE OF CRUCIAL RADIUS DURING TERRITORY ESTABLISHMENT 1. NATIVE GRASS 2. INTRODUCED GRASS 3. CHEATGRASS 4. MEADOW 5. BIG SAGEBRUSH 6. LOW SAGEBRUSH 7. MOUNTAIN BRUSH 8. CONIFER 9. PINYON JUNIPER 10. BROADLEAF TREE 11. GREASWOOD 12. OTHER	MAJOR VEGETATION TYPE IN CRUISING RADIUS DURING NESTING 1. NATIVE GRASS 2. INTRODUCED GRASS 3. CHEATGRASS 4. MEADOW 5. BIG SAGEBRUSH 6. LOW SAGEBRUSH 7. MOUNTAIN BRUSH 8. CONIFER 9. PINYON JUNIPER 10. BROADLEAF TREE 11. GREASWOOD 12. OTHER	MAJOR VEGETATION TYPE IN CRUISING RADIUS DURING POST FLEDGING PERIOD 1. NATIVE GRASS 2. INTRODUCED GRASS 3. CHEATGRASS 4. MEADOW 5. BIG SAGEBRUSH 6. LOW SAGEBRUSH 7. MOUNTAIN BRUSH 8. CONIFER 9. PINYON JUNIPER 10. BROADLEAF TREE 11. GREASEWOOD 12. OTHER	NEST DESTROYED OR ABANDONED 1. BLOWN OUT OF TREE 2. BLOWN OFF CLIFF 3. TOO LARGE, FALLEN 4. TREE BLOWN DOWN 5. ROAD BUILDING 6. URBAN DEVELOPMENT 7. PREDATION 8. ABANDONED 9. OTHER	POSITION OF NEST IN TREE 1. IN CANOPY 2. BELOW CANOPY 3. ADJACENT TO TRUNK 4. ON OUTER BRANCHES 5. IN UPPER ONE-THIRD OF TREE 6. IN LOWER ONE-HALF OF TREE 7. OTHER

Fig. 18. Raptor Nest and Habitat Survey Form.

INSTRUCTIONS FOR COMPLETING RAPTOR NEST AND HABITAT SURVEY FORM

1. Fill out the top line with district and State number, AMS map number (or other map number), nest number (nests will normally be numbered by species of raptor), the date, and the recorder's name.

2. When a nest is located, circle one item in each block of data that most nearly describes the locale.

3. If an item entitled "other" is circled, write in the correct name or number of the item.

4. Place this form in the biologist's field inventory notebook (looseleaf) for future reference. Divide the field notebook into sections for the different species of raptor found within the district (or other administrative unit).

C. Marsh and Shore Birds.

1. Importance of Aquatic Environments. Marshes and other similar semi-aquatic environments are relatively limited on public lands and must be protected for the species that occupy these unique ecosystems. Aquatic environments are highly attractive to a variety of species of birds that cannot survive without this habitat, whether for nesting sites, food, or to fill other requirements. Because of the relatively restricted zone of semi-aquatic habitat that exists around many reservoirs, streams, lakes, etc., many species of birds adapted to these environments have developed some degree of tolerance to members of their own species and to other species that may nest in fairly close proximity. Some marshes are relatively large in extent and contain species exhibiting considerable territorialism. Because of the different responses of different bird species to human disturbance and to each other, a number of different methods should be employed for surveying nesting marsh birds.

2. Tape Recorded Calls. Tape recorded calls may be used to advantage for detecting several species of marshland birds. During the breeding season, many male birds will respond to a recorded call, apparently believing that an intruding bird is in their area or territory. This is especially effective for marsh birds such as rails. Count the number of responses from the males to estimate the total number of mated birds.

3. Plots and Transects. In larger marshes the International Bird Plot Census Method or some other type of spot mapping method may be employed whereby all singing males are recorded and plotted on an area map. If bird occurrence is the primary information desired, a simple line transect may be run through the marsh, recording all birds heard or seen along the transect. If more accurate densities are needed, the Emlen transect or some modification of this method may be used. The observer is cautioned not to try to apply numbers of birds in flocks of colonial species found in restricted localities of a marsh to the marsh as a whole, since one flock or group of colonial birds may be the only group present in a particular marsh. A line transect 4 km long by 20 m wide would give the number of birds per 100 ha.

4. Use of Shore Bird Behavior in Censuses. Many shore birds, such as killdeers and sandpipers, nest primarily in the open areas of beaches or lakeshores. The experienced bird watcher, knowledgeable about nesting habits of different shore birds, can usually find most nests by either walking the shorelines, systematically searching open areas, or by watching the birds from a distant vantage point. Many species of shore birds have some type of ruse or bluff which they use to make humans or other predators think they are crippled and to try to lure them away from the nest. It is almost certain that a nest is nearby if a bird, such as a killdeer, suddenly appears ahead, exhibiting a "broken wing." Many other species show an obvious inclination to remain within a relatively small area, again indicating that a nest is

nearby. Whether the actual nests are found or not, a good indication of the total number of shore birds present may be obtained by counting all of these birds observed as one walks along a beach or through open areas suitable for nesting.

5. Censusing from boats. Some observers sit quietly in a boat or raft at some distance from the shore and use binoculars to count all birds observed along the shoreline. By sitting offshore from 50 to 100 yds, the disturbance to the birds is largely removed and they may often be more readily observed coming and going to their nests.

6. Censuses for Specific Species of Interest.

a. Sandhill Crane. The following is taken from Sanderson (1977):

> Sandhill cranes have been censused on some breeding grounds, wintering areas, and concentration areas during migration. Counting methods vary, the methods used depending upon agency needs and economic considerations. Censuses may be taken from fixed-wing aircraft along transects in specific areas (Wheeler and Lewis 1972) or during aerial surveys for waterfowl. All aerial surveys are subject to much error. The use of different observers from year to year, difficulties in estimating accurately numbers in large flocks while observers are traveling at high speeds, the weather, and the time of day affect reliability of the censuses.
>
> In some circumstances, helicopters are superior to fixed-wing aircraft for counting cranes and locating nests (Valentine and Noble 1970; Williams and Phillips 1972). The use of helicopters for general survey work probably will not become routine, because of the high expense. Nest counts along transect lines are being tested as an index to resident crane populations in Florida. In northern Michigan, cranes build their nests on the ground among trees. In such circumstances nests are easily overlooked, even from a helicopter. Walkinshaw (pers. communication to authors of chapter (Sanderson 1977)) found that considerable ground work, in combination with a survey from a helicopter, was necessary to locate all nests at Betchler Lake in northern Michigan. Counts of cranes leaving and entering roosts in early morning and late evening are commonly used and are as reliable as aerial censuses when only a few thousand cranes use the site. Larger populations on roosts can probably be counted more accurately from aircraft.

Many small marshy and beaver pond areas or other wet meadowlands of the West harbor a few pairs of nesting sandhill cranes. They should be watched for in marshy areas, mountain valleys, or river canyons while doing other inventories or resource work. The birds are sufficiently conspicuous to be seen from long distances with binoculars.

b. Virginia Rails. According to Sanderson (1977),

> No regular, systematic censuses are conducted on Virginia rails. There have been some exploratory investigations, however, to develop field techniques for systematic censusing. In Colorado, J. F. Glahn (pers. communication to chapter authors 1977) used recordings of the grunt call. He played 5 to 10 calls with 20 to 30 seconds between calls at regular stops along a transect. This technique was used throughout the day and night, but best results were obtained in the early morning and late evening hours during the first few weeks of the breeding season. This technique was believed to detect birds up to 100 yards (J. Tully, pers. communication to authors). Pospichal (1952) found drive-trapping and overnight-trapping sets to be effective in obtaining birds for banding. Horak (1964) also used drive-trapping, and Labisky (1959) successfully used night-lighting in connection with mist nets. Tanner (1952), using cloverleaf traps with 25-foot leads, captured 277 Virginia rails and soras over a 2-year period.

c. Black Rail. Sanderson (1977) states:

> It seems that the use of tape recorder playbacks is the most promising technique for investigating the occurrence of black rails. It has worked well on the lower Colorado River in spring and early summer. Fall and winter trials with this technique have been less successful.
>
> In most areas of the United States, counts have been obtained in the spring on birds that were calling on their own volition (Stewart and Robbins 1958:131). Unusual high-water conditions, especially extra-high tides, which force the birds into relatively open situations, constitute another opportunity to estimate approximate numbers. High tides can be accurately predicted and an investigation can be prepared to take advantage of any unusual weather conditions that exaggerate the tidal effect.
>
> For the most part, there seems to be no information available on population trends. The California black rail, however, is believed to have disappeared from virtually all its former salt-marsh breeding grounds on the west coast of the United States.

d. American Woodcock. Sanderson (1977) states the following:

> Singing-ground surveys were initiated by Gustav A. Swanson in Maine in 1936 as a method of determining trends in breeding populations of woodcock. Currently the procedure

consists of driving a randomly selected route approximately 20 minutes after sundown and stopping every 0.1 mile (0.6 km) to count male woodcock active in their courtship displays. Data from many such routes throughout the principal woodcock breeding range provide an index, which is the sole measure of the woodcock breeding population. As an index, singing-ground surveys should indicate major annual changes in the population, but they will not show actual numbers.

Recent unpublished data collected independently by Dilworth in New Brunswick, Krohn in Maine, Rieffenberger in West Virginia, and Whitcomb in Michigan (personal communications 1973) indicate that there may be as many as three noncourting males for each courting male. If the proportion of singing males to nonsinging males varies from year to year or from state to state, the survey is not a valid measure of the relative size of the adult male segment of the spring population. Further, since it appears that some males breed with more than one female, whereas other males do not breed, it is necessary to know the adult sex ratio in the spring to measure the comparative number of females

There have been no significant annual changes in the breeding-population index in recent years.

d. Common Snipe. From Sanderson (1977):

The secretive habits of migratory shorebirds, including snipe, make them difficult to study in many respects. Population estimation is an important management parameter but is also difficult to measure. There are six survey methods recommended as having application in the study of snipe.

1. Bleating or winnowing counts on the breeding grounds.
2. Territorial response involving playback of recorded calls on the breeding grounds.
3. Strip census or King method on both breeding and wintering areas.
4. Direct counts of birds during migration and on wintering areas. This type of count can be aided by the use of delayed-detonating shotgun shells causing birds to flush for accurate counts.
5. The Lincoln-Peterson Index method by capturing and banding or marking, or both, and recapturing snipe in concentration areas.
6. Snipe wing survey to examine and monitor annual productivity and hunter harvest based on the federal waterfowl harvest survey (not yet an operational method).

These techniques will be discussed in greater detail below. The United States Fish and Wildlife Service made attempts in the early 1950's to obtain information on the population

status of snipe. These attempts centered on annual surveys of the breeding and wintering grounds. Later the surveys were terminated for reasons to be explained, but the information gained should be of value in planning future population surveys.

Bleating or Winnowing Counts

Breeding ground estimates for snipe were attempted by the United States Fish and Wildlife Service in a few northern states and parts of Canada by making winnowing counts. This attempt to eventually census large areas of snipe breeding range was discontinued largely because of lack of access to a large portion of the breeding habitat over the vast land area involved. Some additional drawbacks to indexing on breeding grounds are (1) all birds heard winnowing are not paired, (2) both sexes are known to winnow, and (3) factors such as weather conditions, moon phase, time of day, and phase of breeding cycle affect winnowing activity.

Tuck (1972) recommends the use of straight-line census routes to count winnowing birds. Stops should be about every 0.8 km (0.5 mi). The number of birds heard may be extrapolated to include the total area. The peak period for winnowing is during the 10-day interval after the females arrive, and this period is considered to be the most reliable time to census. The timing of this peak of course varies in different parts of the breeding range. The calling period at dusk should be used; this period appears to be more reliable than the dawn period. A rangewide survey might be hampered somewhat by lack of roads through much of the snipe breeding habitat. If one is aware of and takes into consideration the drawbacks, a comparative index can be obtained over rather broad expanses of breeding territory.

Territorial Response

This method involves playback of recorded territorial calls from predetermined locations and enumerating individual responses (Tuck 1972:137, 393). This technique is the most accurate available and allows the pinpointing of males and nest sites for other studies. It can be effectively used over the entire day during the early part of the breeding season. It is more time-consuming than the other techniques but can be used in combination with other indices to census relatively large areas.

Strip Census or King Method

This method is carried out by walking a predetermined route through snipe cover and counting the number of birds and noting the distances at which they flush. The average flushing distance is determined and used to calculate the

effective width of the census strip. The population is the number of birds flushed divided by the area of the strip and multiplied by the total area (Tuck 1972:394).

$$P = \frac{AZ}{ZYX}$$

where

P = population,
A = total area of study,
Z = number flushed,
Y = average flushing distance, and
X = length of line.

This technique has application on both the breeding and the wintering grounds and is stressed for that reason. It probably would be most practicable in localized studies.

Direct Counts

Direct counts of snipe on the wintering ground were also made by the United States Fish and Wildlife Service in the early 1950's, and continued through 1963. Counts were made in snipe concentration areas by local cooperators in 10 to 15 southern states. Supplementary information on snipe numbers was obtained from the National Audubon Society Christmas Bird Count.

This estimate attempt was discontinued because of large variability among years in the number of snipe observed at census areas. Both tidal and upland water levels affected location and size of snipe concentrations as did prevalence of winds and storms. Human disturbance by both legal and illegal hunters was a factor. An unknown number of snipe winter in Mexico and farther south, and the number of snipe wintering in southern United States may fluctuate depending on the severity of winter weather to the north. These locally high changes in bird abundance probably affected the reliability of the overall estimate and masked any actual population changes. A much larger sample size was needed to increase the accuracy and repeatability of the estimates, and perhaps randomization of census areas would have been helpful. The use of delayed-detonating shotgun shells may aid in increasing accuracy of individual counts. These can be fired into fields in other to flush birds for counting.

The Lincoln-Peterson Index

This method involves trapping and banding or marking a portion of the resident population and using the recapture rate to compute the total population. This technique is beneficial on the wintering grounds if high and stable concentrations of snipe are available to work with so as to justify the time

expended. In many situations where a continuous banding operation is in effect, the original Lincoln Index will not suffice; however, modifications are available that may be pertinent to these situations (Jolly 1965).

D. Colonial Water Birds.

1. Role in Aquatic Ecosystem. The colonial water birds, including the pelicans, cormorants, anhingas, frigatebirds, herons, egrets, ibises, storks, spoonbills, gulls, terns, noddys, and skimmers, are responsible for some of the greatest interchanges of energy between the land and water biotas. The impact of serious disruption in this energy flow to the dynamics of estuarine biomass production and that of other inland aquatic ecosystems has never been adequately investigated but must be immense. These birds are integral parts of the ecosystems in which they occur. We have only the faintest glimmerings of what changes would be wrought in those ecosystems should these animals disappear. As one example, speculate on the condition of our beaches if there were no gulls to clean them. Water bird colonies in many locations supply an enormous amount of fertilizer to beaches and coastal uplands. The resulting vegetation often stabilizes sand dunes and other coastal soils against erosion and blowouts. Likewise, heronries nourish plant successional stages and in many places no doubt accelerate succession.

2. Environmental Indicators. At the top of the food chain like the raptors, the colonial water birds are especially vulnerable to pollution and to prey declines. They are indicators or early warning detectors of both conditions. In any event as top predators they need special protection if they are to survive successfully in their man-changed environment. Terns and gulls are used by fishermen to locate bait fish schools being preyed upon by larger sport and commercially valuable fishes.

3. Critical Biological Factors. Appreciating a number of critical features of the biology of water birds is essential if surveys, management, and protection plans are to be adequate. Some of these considerations are as follows:

a. Most colonially nesting water birds are densely packed into only a few small areas while breeding, and thus whole populations are vulnerable to single disturbances. This is in contrast to most noncolonial songbirds, which are widely dispersed in the breeding season, with concentrations occurring mainly during migration and winter.

b. When they are clustered in colonies, water birds must be censused over wide geographic areas so that populations on individual Federally administered areas can be placed in a regional perspective. Knowing the total number of colonies of different species on public lands is highly important if the Bureau is to provide the appropriate management and protection.

c. To offset large colony vulnerability, every effort should be made to provide sufficient habitat for dispersal to as many additional small colonies as can be productive. Each new satellite colony and its occupied habitat should be carefully protected against undue disturbance until they are securely established.

d. Judge habitat suitablility primarily by bird use. Assume that if other locations were suitable and the populations were not declining, those additional sites would be occupied by colonies. The birds have specific instincts which govern their selection of sites to colonize. Regardless of man's view on habitat desirability, frequently habitats that appear completely satisfactory are never used by birds. Occupied sites for any bird species must be considered to be the most important habitats for the birds simply because the birds themselves have selected them.

e. Changes in species' breeding habits and habitat preferences may occur as a result of human disturbance. There are indications that habitat preference changes are taking place now in such species as least terns (resorting increasingly to flat rooftops), herring gulls, and common and roseate terns (nesting in open, unprotected marshes). Oyster catchers are nesting more often in salt marshes instead of their usual sandy beaches where human disturbance is more severe. For most of these birds, we have reason to fear severely reduced productivity in their new colony habitats, although this condition might change with time as the species hopefully adapt. Ditching of salt marshes on Long Island, NY, has resulted in astounding changes in the breeding biology of seaside sparrows, from colonial and nonterritorial to solitary and territorial. When similar behavioral changes occur in any colonial water birds, management practices have to be reassessed. Habitat preference changes may in fact be revealing changes in bird behavior caused by stresses from man's activities, which may ultimately cause the demise of some bird populations.

f. Habitat requirements even for very closely related species may differ so much that no one habitat will provide optimum conditions for all species. Minor and sometimes exceedingly subtle differences in vegetation, topography, etc., may determine the presence or absence of individual species.

g. Many species will not renest if distrubed or if the colony is forced to move, which can be disastrous and locally fatal. Species already stressed by other factors such as pollution, habitat, or food reduction, or for species having small clutches, short life spans, or heavy winter migration mortality are particularly vulnerable. Once established, colonies should be given absolute protection until all adults and young have departed.

h. Colonies are most likely to desert during the courtship and nest-site selection stages and least likely to desert when young are present. This is a generality, and there are individual bird, species,

and even colony, differences. Likewise, there is an intermediate likelihood of desertion during the egg-incubating stage. The degree of colony protection should be tied to the stage in the nesting cycle.

i. The mere movement of a colony from one site to another following disturbance is no indication the move will be successful. It is not uncommon for a disturbed colony to move and then experience total failure to produce any eggs or young after initial reestablishment. Failure can be from many causes, frequently different in each case. One underlying explanation is the tremendous loss of energy involved in fruitless courtship, egg laying, incubation, etc. Most colonial water birds do not have two broods, probably because of a combination of energy and time limitations.

j. Animals at the edges of their geographic ranges are under appreciably greater stresses than those toward the centers. Exposed to different climatic extremes, novel food, strange habitats, and sometimes different competitors, animals that are pioneering range expansions frequently have lowered breeding success than normal for their species. Colonies appear and disappear with more than usual frequency; thus, they need extra measures of protection until the new population is well established. Usually, an expanding population is a healthy population, while a declining population is experiencing one or more problems.

k. Regional "seed" colonies need greater protection than less important colonies. In many areas some colonies always seem to be more important than others as the source of individuals establishing new colonies. These "seed" colonies need special protection and management, since regional productivity, expansion, and recruitment are tied directly to them.

l. Despite the advantages of dispersal into numerous small colonies, in many species there appears to be a minimum number of colony individuals below which reproductive success of the colonies declines rapidly. Several explanations for this have been advanced, including: (a) colony members use each other as cues in locating patchy food sources such as fish schools; (b) the presence of a certain number of conspecifics is needed to provide the social stimulation required for successful courtship, pair formation, and reproduction; and (c) in larger colonies, the proportion of individuals exposed to predation on the colony's edge is less than in smaller colonies. These three factors are not mutually exclusive processes but serve to emphasize that colonial species generally do not survive except colonially and that they need man's help once he has disturbed natural processes.

m. Many colonial species also need extensive and reasonably close protected areas for feeding, resting, bathing, and other nonbreeding activities. Protecting the nesting site alone may not fill the needs of the specific birds in the colony.

4. Purpose of Surveys and Censuses. The ultimate purpose of surveys and censuses is to protect colonies and manage their habitats so they can exist safely with minimal human disturbance. To protect

colonies, we must first locate all of them and then determine their composition. All survey activities result in some disturbance to the nesting birds. A method that does not disturb the birds at all in one area might cause colony abandonment in another area, or in another species, or at some critical stage in the nesting cycle. Biologists must be ever alert to signs of problems caused by their surveys or census activities and cease activities around colonies if they appear to be disrupting the birds' nesting cycle. A few factors to keep in mind in planning to survey colonial water birds are as follows:

a. Latitudinal differences produce differences in breeding time in the same species.

b. Both early and late breeding species at the same latitudes may exist.

c. Differences in arrival time at the same colony within one species may occur; experienced breeders generally arrive first, neophytes, last.

d. Relative numbers of adults present at a colony vary with species, time of day, stage in the breeding cycle, etc.

e. Biologists should avoid surveying or censusing during courtship or egg-laying when birds are most likely to desert.

f. Consistency is essential for year-to-year comparisons once the proper time for surveying or censusing is chosen. All surveying or censusing in succeeding years should be done in that same time period, allowing for annual weather variations.

g. Three proven methods of data recording should be used : written notes, photo augmentation (whenever possible), and tape recordings. Tape data should be recorded in the field only in one of two forms: (1) number of nests with eggs or young (by species), or (2) number of adults present in the colony. Once chosen, stay with one system.

h. No one figure for the total number of breeding pairs in any colony exists. Pairs, or members of pairs, are emigrating or immigrating (coming and going), dying, failing to lay, failing to hatch or fledge any young, etc. Birds might be paired early in the season but not later or the reverse, etc. Only strive to approximate the number of breeding pairs at some particular time--hopefully at maximal colony occupancy. Do not spend a large amount of time at a colony trying to arrive at precise figures, unless this can be done from a distance to preclude excessively disturbing the birds.

5. Clues to Colony Existence and Location. Locating colonies is not always easy for they are not always obvious. Great blue heronries in the tallest treetops of densely wooded river bottoms may be passed by unnoticed if surveying is done from the ground. Locating suitable habitat is the first requisite, although what is "suitable" for

many species is rapidly changing with human encroachment on traditional habitats. Do not develop stereotypes about what are likely habitats; new colonies in new habitats are overlooked this way. This applies equally to nesting sites for raptors and many other groups of birds that may utilize entirely different types of vegetative substrates or types of habitat for nesting in different states. Several clues can be helpful in approximating colony locations, but the presence of nests and eggs is always the only verification of a breeding colony. Previous colony sites (determined from the literature), local experts, or oral tradition should always be investigated first. Even if unoccupied early in the season, recheck sites periodically. Begin all surveys by checking old colony sites. Indicators of active colony sites include the following, with much variation depending on species:

a. Adults in breeding plumage persistently flying over, into, or around one location in suitable habitat.

b. Persistent clustering of adults in one place above the high tide or high water mark; this is especially true of gulls, terns, and skimmers.

c. Breeding, plumaged adults carrying food or nest material (twigs, sticks, shells, grass, etc.) to one location.

d. Courtship behavior and displays, or copulations, in, on, or over small areas.

e. Roosting at night in one particular area, especially by herons and ibises.

f. Adults dive-bombing persons or animals when they intrude on specific areas in suitable habitat.

g. Clusters of adults regularly spaced from one another on the ground (terns, gulls, skimmers) or in trees and bushes (herons and ibises), especially other than at dusk.

h. Whitewashed and/or smelly areas with suggestions of nests or with nest "scoops" and many birds' footprints.

i. Clustered adults sitting on the ground or in trees and bushes, allowing unusually close approach before flushing and then returning to the same spots.

6. Surveying Techniques. Surveying is the process of locating active colonies. Recommended techniques are as follows:

a. Aerial Surveying. Where conditions and species permit, aerial surveying is the fastest, most efficient method and allows the widest coverage in the shortest possible time, essential for one-shot replicable work. Small (two- or four-seat) helicopters are better than fixed-wing aircraft in most cases because they are more maneuverable,

have no stalling speed problems, and can come in closely and slowly. They cost far more to rent than fixed-wing aircraft; however, the disturbance is controlled and short-lived, and in that time very much useful data can be obtained if the birds tolerate the disturbance. Funds, species, and experience must dictate the choice of aircraft. Some considerations in the use of aircraft are as follows:

(1) Limitations on Aerial Surveying. Aerial surveying is not simple. Some species are more easily seen from the air than others; some refuse to flush from cover; and different cruising altitudes are better for certain species. Only experience can dictate the most appropriate procedures for any particular area.

(2) Photo Augmentation of Aerial Surveys. Aerial surveying should be supplemented by photographing where this can be properly done. Motion, vibrations, window distortion, species visibility, and difficulty in identifying some species are problems frequently encountered in aerial photography.

(3) Value of Small Helicopters. Small helicopters allow simultaneous surveying and censusing--judiciously flushing the birds for counting and allowing landing near the colony for determinations not possible from the air. If done properly, no additional visits are necessary to ground-truth the aerial data.

(4) Use of Personnel in Aerial Surveys. Helicopter and fixed-wing surveys are best done by three or four persons, although they can be effectively done by one experienced observer-pilot. One pilot, one right-side and one left-side observer, with possibly a fourth person as recorder (and/or photographer), have proven to miss the least information. This combination of personnel also has the added advantage of providing several different simultaneous assessments of numbers and species composition in difficult cases. One agreed-upon set of figures can then be obtained. Note: Make sure fixed-wing aircraft is capable of carrying four persons and still maneuvering; aircraft may be too fast unless equipped with special stall equipment.

(5) Notification and/or Coordination with State Wildlife Agency. Since all water birds are protected by State and Federal laws, advise the state wildlife agency and, where possible, coordinate with it in all proposed surveys. Avoid duplicating surveys between agencies.

b. Ground Surveying. Surveying from the ground, whether by vehicle, boat, horseback, or on foot, is undoubtedly the cheapest type of surveying. However, it frequently misses whole colonies and does not usually investigate "unsuitable" areas. It takes an extremely long time to accomplish, does not allow uniform coverage of large areas in short periods of time, and can cause severe disturbance. Nonetheless, ground surveying should be done if aerial surveying is impossible. When nonaerial surveying methods are used, colonies can exist for one or

more years without being discovered, thus delaying protective and/or management measures. Survey by traveling through all suitable-looking habitat and watching for birds or signs of nests.

c. Earth Satellites. While their data are not yet available for general examination, earth satellites are obviously the method for future surveying. They provide nondisturbing, constant, and periodic coverage at several wavelengths. Once agencies have access to the technology necessary for this work, they will be able to routinely survey water bird colonies merely by obtaining data from passing satellites.

7. Censusing Techniques. Censusing refers to the observing and recording of species and numbers of colony inhabitants. Procedures and special considerations are as follows:

a. Aerial Censusing. Essentially the same constraints and considerations apply for censusing as for surveying. However, the balance is much more favorably tipped in favor of the helicopter over fixed-wing aircraft in doing census work. Accurate censusing of mixed species tern or white heron colonies, for example, is difficult at best in a fixed-wing aircraft, but much easier in small helicopters.

b. Photography. Photo backup may be more essential in censusing than in colony surveying. Again, better photographs at lower altitudes may be obtained from helicopters than from fixed-wing aircraft. The helicopter also permits landings near the colony where birds may be photographed against the sky for later counting.

c. Ground Censusing. Ground or water-based censusing, like surveying, is feasible, cheap, and unlike surveying, covers all the colonies, once located. But it is more time-consuming and generally disturbs the birds more over a lengthy period, so that short-term, comparable, state-in-cycle data are harder to obtain over the years. It also usually involves many more observers at different times in various areas than helicopter censusing, and each additional, isolated observer is another source of data error.

d. Identifying Species and Estimating Numbers. Regardless of how colonies are reached, census takers should have experience or training in arriving at reasonably precise and hopefully accurate figures. Not all are equally capable of acquiring and perfecting this skill. Even species identification can sometimes be a problem. Greatest attention should be paid to resolving these two problems, or much effort will be wasted.

e. Ground-Truthing Aerial Data. Whenever incomplete aerial censusing is not accompanied, for whatever reason, by on-the-scene verification while on the ground, later trips will have to be made into the colonies for this "ground-truthing." Each such trip is not only additional disturbance but inevitably occurs some time after the initial data are taken. Frequently, the ground data will then differ from the aerial data, even if taken by the same observer(s), since actual colony size fluctuates over the breeding season.

f. Recommended Observer Behavior at Colonies. Whenever observers must enter a colony on the ground, they should plan their activities before entering to remain the shortest possible time. Groups should be small and the individuals should stay close together. Entry should be avoided, if at all possible, during the heat of the day, and when it is cold, windy, or rainy (especially if all three). Wear subdued clothing, move deliberately, and do not procrastinate. The longer an observer remains in a colony, the better are the chances that avian predators will be eating eggs or young while their parents are off the nests. Do not make frequent incursions into a colony. The more often observers enter a colony, the more likely it is that mammalian predators will follow their trails into the colony that night.

g. Prohibited Behavior. Do not touch or otherwise disturb eggs, nests, or young. Do not attempt to replace any eggs that have been rolled or been kicked out of nests, or to return any young that seem to have strayed. Eggs that are away from the nest are probably already addled and replacing such eggs could interfere with subsequent incubation. Never chase young to count them; just count from a distance and leave.

8. Colony Monitoring. Colonies should be monitored on an irregular basis to be sure that they have not moved or been disturbed and that all protective measures instigated by the district are still in effect. Disturbance during such monitoring should be minimal.

E. Sea Birds.[1/]

1. Selecting Census Technique. The ultimate aims of the census program determine the intensity and precision of any sea bird census technique. For example, a survey of breeding birds over a large geographic region in a single season may require a less precise and time-consuming technique. If the prime objective is to assess changes in local population levels, a detailed permanent census plot system is the most adequate procedure. In many cases, however, the species involved, the accessibility of the breeding colonies and nesting habitats, and to some extent time, weather conditions, topographic features of the area, and manpower, also play an important role in the final selection of a census technique. In addition, colony size influences the technique selected (especially where time is short). In small colonies (less than 2,000 pairs), make direct counts of all birds and/or nests; if the colony is larger, census only a proportion of the total population according to the appropriate counting method determined for each species.

[1/] Censusing techniques for sea birds has been reproduced by permission of the Minister of Supply and Services, Canada, from Canadian Wildlife Service Occasional Paper No. 25, Catalog Number CW69-1/25.

2. Colony Description. It is extremely important to describe each colony in detail giving as much information as possible about its structure and associated habitat and physical features. This procedure will include preparing two sketch maps, photographing the colony and census areas, and providing precise details of each census area and census technique.

3. General Sketch Map. Show the location of each colony or area censused to ensure that comparative counts can be made in the future. If an area is large and the associated bird distribution small and/or aggregated, draw an inset map showing the nesting sites in relation to distinct natural features of the total region.

4. Detailed Sketch Map. Define the limits of the colony being censused and show with precision the census methods used to determine population size. In preparing any sketch map of the limits of a colony, show these boundaries in relation to main features of the region such as gullies, streams, faultlines or crevices. These permanent reference points or landmarks are invaluable to other observers in recognizing the census area in future years.

5. Photographs. The colony and census areas should be photographed to provide a permanent record of colony size, structure, and locations, which can be used to draw accurate boundaries of colonies and study plots (census transect lines, quadrats, etc.). The best method is to use a Polaroid camera so that areas counted or censused can be marked directly onto the print in the field (Polaroid camera using film type 105 permits producing both a print and a negative). When photographing a colony, be sure to record the photographer's name, location (show position and direction to subject for each photograph taken on the general and/or detailed sketch maps), date and time, camera and lens types, film type, shooting detail (subject, distance, scale, etc.), and weather conditions.

6. Extent of Each Census. It is important to describe the completeness and exactness of the census. For example, were any areas overlooked or inaccessible and if so, to what extent? Note the proportion of total colony not censused, etc.

7. Phase of the Breeding Cycle. The census of breeding birds at colonies is normally conducted during the middle and last half of the incubation period of the species involved, although in some cases the best time for census activities is at earlier (e.g., black guillemot) or later phase (e.g., Leach's storm-petrel) of the breeding cycle. However, even where the breeding time of a species is well known, it is important to estimate the phase of the breeding cycle for the population at the time the census is made. Record the nest contents (e.g., four eggs, or two eggs and two chicks, or four chicks, etc.) for an adequate sample of nests examined at random within the census area. This information will assist in interpreting the census and increase its comparative value. Enter the results on the Seabird Colony Census (Fig. 19) under phase of breeding cycle at time of census and/or special notes.

Fig. 19. SEABIRD COLONY CENSUS
FIELD TABULATION FORM

COLONY

1. Name:
3. Position:
(latitude) (longitude)
4. Situation:
5. Size (hectares):
7. Species:
8. Other species:

2. Census date:
(month) (day) (year)
6. Observer:
(name)
(address)

9. Type of census (census technique):

10. Reliability of total census:

11. Weather during census:
12. Wind during census: 13. State of sea:
14. State of tide during census:
15. Time of census to (time zone:)
(start) (end)
16. Numbers of observers: (names:)

17. Number of breeding birds: individuals or pairs (circle one)
18. Reliability of count of breeding birds:

19. Total population estimate: (leave blank)
20. Status of population: 21. Phase of cycle:
22. Breeding details collected:
23. Type of nesting habitat:

24. Condition of nesting habitats and birds:

25. Disturbance factors:

26. Photography:

27. Special study:
28. Special notes:

General Instructions
for
Seabird Colony Census Field Tabulation Form

The following is an explanation of the Colony Census Field Tabulation Form. Each data item listed below is to be completed when conducting a colony census (leaving item 19 blank) and recorded on the form. Using the codes indicated, the data may readily be placed in a computer data file.

Data item	Instructions for completing Seabird census form
1. Colony name:	Official name and local name(s) if different; also state.
2. Census date:	Month, day and year.
3. Colony position:	Latitude and longitude in degrees and minutes.
4. Colony situation:	Located on: (1) island, (2) mainland, (3) other.
5. Colony size:	Total area of colony (nesting space) in hectares (1 ha=10,000 sq. m or 2.47 acres).
6. Observer:	Same (first name and surname) and address.
7. Species name:	common and/or scientific name (use AOU Check-list of North American Birds. 1957).
8. Association with other species:	(1) no (i.e., not associated with other spp.) (2) yes (i.e., mixed colony--list other breeding species present).
9. Type of census (census technique):	Record type of census using categories listed below and give complete details-- (00) no data, (01) visual estimate--ground, (02) visual estimate--air (specify aircraft type, etc), (03) visual estimate--sea (specify boat type, etc), (04) total ground count of individuals, (05) total ground count of nests, (06) line transect and quadrat census, (07) photographic count--ground (specify camera type, etc.), (08) photographic count--air (specify aircraft and camera types), (09) photographic count--sea (specify boat and camera types, etc.), (10) other.
10. Reliability of total census:	(1) observer feels data are quantitatively comparable with those collected in good conditions (e.g. comparable with earlier census, sufficient time, good weather, etc.); (2) observer feels data are not representative--give details.

Data item	Instructions for completing seabird census form
11. Weather during census:	Select one of the following categories and provide details where necessary-- (0) good (none of the following), (1) drizzle, (5) fog, (2) light rain, (6) hail, (3) heavy rain, (7) snow, (4) intermittent showers, (8) other conditions (give details).
12. Wind during census:	Assess wind speed with an anemometer (if available) or using sea-surface conditions according to the Beaufort Scale:

Beaufort number	Description	Effect caused by wind at sea
0	Calm	Surface mirror-like
1	Light air	Only ripples form
2	Light breeze	Small, short wavelets, distinct but not breaking
3	Gentle breeze	Larger wavelets beginning to break, glassy foam, perhaps scattered white horses
4	Moderate breeze	Small waves still but longer, fairly frequent white horses
5	Fresh breeze	Moderate waves, distinctly elongated, many white horses, perhaps isolated spray
6	Strong wind	Large waves begin with extensive white foam crests breaking; spray probable
7	Stiff wind or moderate gale	Sea heaps up, lines of white foam begin to be blown downwind
8	Stormy wind or fresh gale	Moderately high waves with crests of considerable length; foam blown in well-marked streaks; spray blown from crests
9	Storm or strong gale	High waves, rolling sea, dense streaks of foam; spray may already reduce visibility
10	Heavy storm or whole gale	Heavy rolling sea, white with great foam patches and dense streaks, very high waves with overhanging crests; much spray reduces visibility

Data item	Instructions for completing seabird census form
13. State of sea during census:	Select category below and where necessary elaborate using the Beaufort Scale (see item 12)-- (0) no data, (1) flat calm, (2) light sea (4 ft or less), (3) medium sea (4-10 ft), (4) heavy sea (10-20 ft), (5) rough sea (over 20 ft), (6) no waves but considerable swell, (7) little sea but considerable swell.
14. State of tide during census:	Select one category below and elaborate where necessary-- (0) no data, (1) high, (2) low, (3) half ebb, (4) half flood, (5) storm.
15. Time of census:	Local time and time zone (e.g., EST--Eastern Standard Time, ADT--Atlantic Daylight Time, etc.) at both start and end of census, and use military time (e.g., 1:00 PM = 1300)-- (1) start time (census initiated), (2) end time (census completed).
16. Number of observers:	Total number of workers and name of each.
17. Number of breeding birds:	Total number of birds expressed as individuals or pairs (the census technique employed will determine whether the count will be expressed as individuals or pairs; for example, a count of active nests will be given as pairs whereas a count of standing adults would be recorded as individuals).
18. Reliability of count of breeding birds:	Select one category below and elaborate giving complete details-- (0) actual count, (1) 5%, (2) 10%, (3) 15%, (4) 20%, (5) 25%, (6) 30%, (7) 40% (8) greater than 40%

Data item	Instructions for completing seabird census form
19. Total population estimate:	Estimate of total population size given as number of individuals (field observers do not determine this population parameter; it will be calculated, where possible, by appropriate office staff after reviewing all available information for the colony).
20. Status of population:	Select one category and elaborate if necessary-- (0) no data, (1) stable, (2) increasing, (3) decreasing.
21. Phase of breeding cycle at time of census:	Select one category below and state where details of breeding information are located (e.g., see item 22 and item 28, Special note No.)-- (0) no data, (1) prelaying, (2) egg-laying, (3) incubation, (4) hatching, (5) downy young, (6) feathered young, (7) young flying or ready for flight, (8) other (e.g., see Special notes).
22. Breeding details collected:	Select category below and state where information (when available) is filed (e.g., see Special notes)-- (1) yes, (2) no.
23. Type of nesting habitat:	Brief description of typical nest-site situation of breeding birds in the colony (e.g., grassy-turfed maritime slope, bare rock cliff ledges, etc.).
24. Condition of nesting habitats and birds:	Select one category below and give complete details where necessary-- (0) no data, (1) good, no obvious disturbance, etc., (2) poor (give level of disturbance and source, e.g., human activity--shooting--several wounded and dead birds examined, etc.).
25. Disturbance factors:	If source of disturbance noted in item 24 is known, record available information in as complete detail as possible.
26. Photography:	Brief description of extent of photography used during the census and where material is filed.

Data item	Instructions for completing seabird census form
27. Special study:	If colony is being used for a special study (e.g., reproductive ecology of Herring Gulls, Larus argentatus, etc.) select one category below and elaborate on nature and time span of study-- (0) no data, (1) breeding study, (2) experimental study (e.g., control, etc.), (3) other (give details).
28. Special notes:	Used when amount of information recorded for any of the items listed above is too lengthy to be given on the field form. (Special notes should be numbered successively for each colony census of a particular species population, starting with Special note no. 01).
29. General sketch map:	See instructions given in section Description of the colony and when preparing map include scale, north heading, compass coordinates, and colony locations (for examples see Figures 1a, 2a, and 3a).
30. Detailed sketch map:	See instructions given in section Description of the colony and when preparing map include precise details of census technique and procedure; locations of transect lines, quadrats, sample plots, etc.; scale; north heading; and compass coordinates (for examples see Figures 1b, 2b, and 3b).

8. Miscellaneous Observations. It it important to record and comment upon any outstanding or unusual features of the colony, particularly those concerning census procedures and the condition of nesting habitats and birds. Examples may include:

a. The occurrence of high bird mortality within the colony supported by accurate counts of broken and/or deserted eggs and dead and/or dying birds, with comments on the suspected or known causes.

b. The presence of avian and/or mammalian predators at the colony.

c. The existence of human disturbance with a description of the level of activity (i.e., none, light, medium, or heavy) based on immediate and observable activity (e.g., shooting or hunting of nesting birds, drowning of birds in fish nets placed close to the colony, etc.). Also report any potential activities (e.g., proposed construction of power plant, refinery, etc.) which may result in environmental damage to the colony either directly or indirectly.

d. Any information which will facilitate a repeat census of the colony in the future--one conducted in a way virtually identical to the baseline census and therefore permitting a precise measurement of change in bird numbers. In most cases, information of this kind is recorded on the field form Seabird Colony Census, (Figure 19) under the appropriate section heading and/or given as a special note at the bottom of the form.

9. Censusing Birds at Sea.

a. Quantitative observations of sea birds at sea provide a reliable estimate of bird numbers, diversity, and numerical ratio of species. These can be used as a measure of populations over either a small or extensive water area of coast or sea. The method is the same whether the intent is to perform a regular route census between two close geographic points for an index of species occurrence or to chart the distributions of sea birds at sea to clarify aspects of individual species' pelagic ecology.

b. The observer must record birds observed with the unaided eye (binoculars are used only to identify species) along the coast (inshore and offshore) or at sea (pelagic) in a standardized manner based on a ten-minute observation period. Observations should be made from a moving ship, but ten-minute watches from a stationary vessel are acceptable provided that it is made clear in the records that the ship was not moving.

c. The four basic factors to note for each ten-minute watch are: time, position, species and numbers of species, and weather conditions as follows:

(1) Record the time at start of the ten-minute watch. (Note whether DST, ADT, AST, etc.)

(2) Record the position at start of the ten-minute watch. (A map showing the exact route would be most useful.)

(3) Count and identify all birds sighted during the ten-minute watch; give an estimate of the accuracy of identification and count (e.g., murre sp.--could have been a razorbill; 100 eiders ± 10%); add anything significant about their behavior (e.g., following the ship, feeding, sitting on the water, direction of flight); also note plumage differences (e.g., ages in gulls, color phases in fulmars and jaegers).

(4) Record weather conditions during the watch and make a point of noting anything such as fog, rain, high seas, sun-glare, etc., which may have hampered observations.

10. Census Techniques for Individual Species.

a. Northern Fulmar (Fulmarus glacialis).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, vegetation, etc.).

(c) Make detailed sketch map (to scale) of each colony showing limits of the colony (use main physical features as landmarks) and outline and estimate of the total nesting area.

(d) Photograph each colony.

(2) Census Techniques.

(a) It is usually difficult to determine the number of breeding pairs at a fulmar colony because of the presence of prospecting birds (nonbreeders and immatures) which may occupy ledges for several years before producing an egg. Consequently, the most satisfactory census method is to make a detailed survey of each colony and count all apparently occupied nest sites in the colony or census plots. Although this gives the number of nest-site holders rather than the number of true breeders (i.e., pairs that occupied a site and laid one egg), it does provide a reliable index of population size. Follow the procedure outlined below.

(b) The number of birds occupying ledges fluctuates irregularly within fairly wide limits (three to six days) throughout the breeding season. Consequently, counts should be made over a series of three to seven days to determine the average number of birds, both pairs and singles, in attendance at the colony (or representative study plots). Make the counts between 1200 to 1300 hr (maximum extremes: 0900 to 1600 hr) as attendance is highest towards

midday. (See below for time of breeding cycle in which to census.) Record the status of sites as: site and two adults, site and one adult, site with no adults, or site with egg or young.

(c) A reliable index of population size cannot be obtained without a series of counts because daily attendance at the colony is variable (even when the count is taken at the same time of day on consecutive days). The three-to-seven day series provides an accurate average occupancy figure and also maximizes the likelihood of identifying those sites where an egg is under the attending adult, to calculate the percentage of occupied sites with eggs.

(3) Time of Census. The best time to census is the middle two weeks of the 49-day incubation period, when breeding birds sit tight and many pairs are together on the ledges, and when the chance of missing birds which have lost eggs and departed from the colony is lowest.

b. Leach's Storm-Petrel (Oceanodroma leucorhoa).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, vegetation, and cover, etc.) and divide into subareas according to burrow density, if necessary.

(c) Make detailed sketch map (to scale) of each colony showing: (1) colony limits (use main physical features as landmarks) and subareas, and (2) outline and estimate of the total nesting area.

(d) Photograph each colony.

(2) Census Techniques.

(a) Counts of Burrows in Accessible Habitat. Counts of burrows provide an accurate measure of the size of the breeding population in a colony, though it may be impossible to count or estimate numbers at small colonies with a low density and patchy distribution of burrows. In general, the best method is a systematic count and inspection of all burrows to determine the number of occupied burrows (i.e., burrows with an egg or chick). When colonies are large, the determination of their abundance depends on sampling the total nesting area (or subareas) using one of the following methods, which are given in descending order of reliability:

i. Line Transect Method. Place fixed line transects (assign each line a letter--A, B, C, etc.) across the colony from edge to edge to ensure total coverage of the colony and to detect changes in numbers at the periphery in future years. The number of

transects depends on colony size and time available, but a minimum of three transects comprising at least 30 quadrat samples are necessary. Permanently mark each transect line by placing stakes or some suitable markers at both ends of the line and at regular intervals along the line if the transect is extremely long. Mark points along the line at 1 m intervals and use each point as a corner of 1-x 1-m quadrat for a high density (5 x 5 m for medium or 10 x 10 m for low density). If transect is very long, select sample quadrats at regular intervals along the line beginning at the front of the colony. Measure the following characteristics within each quadrat: (1) burrow number and status--count all burrows in quadrat and determine status of each, either active (with egg, chick, etc.) or inactive (unoccupied); record inaccessible burrows, but note any nest not checked; avoid disturbance of nesting birds as they may desert; also use extreme caution when examining a nest as the single egg is very fragile; (2) habitat description--describe habitat of each quadrat, including vegetation and cover, angle of slope, position within colony (peripheral edge of central region); (3) distance from front of colony--record distance from farthest side of quadrat to origin of transect line.

ii. Subarea Sample Method. Make direct counts of burrows in as many 1 x 1 m (or 5 x 5 m or 10 x 10 m) quadrats within the defined subarea as time permits (a minimum of ten quadrats per area or subarea). Select quadrats at random, although samples should be as typical of the subarea as possible, and record (as with the line-transect method): (1) burrow number and status, (2) habitat description, (3) distance from front of colony.

(b) Counts of Birds in Inaccessible Habitat. There is no method of reliably determining or estimating the population size at nest sites which are inaccessible. It is possible to provide an index of the population with the capture-recapture method or flight-activity and/or flight-call rate, but both techniques have serious shortcomings; the first because of movement of nonbreeding birds between colonies and the second due to large changes in daily and seasonal activity patterns. Consequently, counts using any of these approaches are of very limited value.

(c) Time of Census. Census during the last half of the incubation period and keep disturbance to a minimum, as this species deserts readily during incubation.

c. Gannet (Morus bassanus).

(1) Census Techniques. Procedures used to census gannets in the North Atlantic have ranged from simple visual impressions of bird numbers from both land and sea to detailed ground counts of nests.[1/] Ground counts cannot be made at most colonies because of the

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1/ Nettleship, D.N. 1976. Census techniques for seabirds of Arctic and eastern Canada: Occasional Paper No. 25, Canadian Wildlife Service.

inaccessibility of the nesting habitat. Moreover, it is difficult to divide a large colony into small sections and make a systematic search. The most satisfactory method of population analysis is from aerial photography[2/] by taking a series of overlapping photographs during the incubation period from a light fixed-wing aircraft using a 70-mm camera with standard lenses (100 or 150 mm) and black-and-white film (Plus-X professional) at a distance from the colony of about 550 to 600 m. Delimit the nesting areas on 18- x 25-cm glossy enlargements and count individual nests under a hand lens (8x) using a plastic grid overlay. Since only attended nests are counted and the status of each nest is unknown, this assessment of breeding population represents the number of nest-site holders rather than the number of true breeders (i.e., pairs that built a nest and laid one egg).

(2) Time of Census. Census during the last half of the incubation period. In North American colonies, that is late June to mid-July.

d. Great Cormorant (Phalacrocorax carbo) and Double-Crested Cormorant (Phalacrocorax auritus).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, etc.).

(c) Make detailed sketch map (to scale) on each colony showing: (1) limits of the colony based on natural features, (2) outline and estimate of total nesting area, and (3) in mixed-species colonies, distribution of each species within the total nesting area.

(d) Photograph each colony.

(2) Species Identification. It is difficult to distinguish between these two species unless at close range, especially after early June. The less common great cormorant is often misidentified as double-crested. The recognizable features are:

(a) Body size--Great is slightly larger (20-30%) than double-crested.

(b) Bill size--Great's bill is considerably longer and wider than the double-crested's.

[2/]Barrett, J.H., and M.P. Harris. 1965. A count of the gannets on Grassholm in 1964. Brit. Birds 58: 201-203.

(c) Throat-pouch color--Great has yellowish gular pouch with white hind border, and double-crested has orange-yellow gular pouch which lacks a white hind border.

(3) Census Techniques.

(a) Counts of Nests in Accessible Habitat. Make accurate nest counts in a single species colony with direct counts of all nests located on either cliff ledges or in trees. (Where possible, record status of nests separately as: nest and eggs, nest and chicks, or nest with adults only. However, in mixed-species colonies you may have some difficulty in establishing species identity for nests where the owners are absent. When censusing, keep disturbance to a minimum and make the count from as far away as possible to not attract gulls and other avian predators who take exposed eggs or small young.

(b) Counts of Nests in Inaccessible Habitat. Where it is not possible to census a colony from land (e.g., treetop nesting colony with thick undergrowth and/or diffuse nature) or sea (e.g., top of unclimbable rock stack), make an accurate count by aerial photography using a 70-mm camera with standard lenses (100 and 150 mm) and black-and-white film. Individual nests are visible on 18- x 25-cm glossy enlargements.

(c) Time of Census. The ideal time to census single-species colonies is midway through the nesting period when young are too large to be taken by gulls and yet too underdeveloped to leave the nest prematurely. Visit mixed colonies early in the nesting season when distinctive plumages make each species more recognizable.

e. Gulls (Larus spp.).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, vegetation, cover, etc.) and divide into subareas according to density if nests are scattered or clumped.

(c) Make detailed sketch map (to scale) of each colony showing: (1) limits of the colony and subareas (use main physical features as landmarks or reference points), (2) estimate of total nesting area, and (3) species composition--single-species colony or associated with other gulls and non-gull species (if colony is mixed, outline the distribution of each species within the colony if possible).

(d) Photograph each colony.

(2) Census Techniques.

(a) Methods for Deriving Estimates of Numbers. Derive gull census figures by one of several methods, including: (1) full nest count (a nest is considered to be any structure more elaborate than a simple scrape--it must have some built-up edge to qualify); (2) nest estimate using line-transect techniques to sample the total nesting space; (3) breeding-pair estimate by a boat count of adults standing or flying over the colony multiplied by the ratio of nests to adults recorded on control areas selected prior to the boat count; (4) boat count of adults alone; or (5) aerial estimation and photography.

(b) Census Technique Selection Factors. The selection of a technique depends largely upon the accessibility of the colony, the time available, and the degree of precision required. The most satisfactory method is a direct count of all nests in the colony, but a sampling procedure may be required at very large colonies or where nests are located in dense vegetation. Restrict counts of birds alone to sites where nests are not visible and are inaccessible, or when time is short, as estimates using these techniques are subject to a high degree of error.

(c) Counts of Nests in Accessible Habitat.

i. Open Land Areas. Make a detailed survey of the entire area of the colony and count all nests. Survey colony systematically and mark each nest counted with spray-paint to avoid an omission or double count.

ii. Dense Vegetation. Estimate the number of nests in dense vegetation by performing the following work sequence: (1) delineate the colony boundaries (occupied area), (b) divide the colony into subareas based on density (density estimate determined by using binoculars to observe birds flying away and/or roosting), (3) sample colony subareas using one of the following methods, given in descending order of reliability:

Method 1: Line Transect (strip transect)--Place two fixed transect lines (10 m apart, but quadrat size can vary with nest density) across the colony from edge to edge to ensure total coverage of the colony or subarea. The number of transects depends on the colony size and time available, although several transects should be done. Permanently mark each transect by placing stakes or some suitable markers at both ends of the line or at regular intervals if the transect is extremely long. Mark points along the transect lines at 10 m intervals and count the number of nests in each 10 x 10 m quadrat (or what size is indicated by nest density). If transect is very long, select sample quadrats at regular intervals along the lines beginning at the front edge of the colony or subarea. Record data for each quadrat separately and in order. Extrapolate an estimate of the total number of nests in order. Extrapolate an estimate of the total number of nests in the colony or subarea. Record data for each quadrat separately and in order. Extrapolate an estimate of the total number of nests in the colony from the transect nest density figures.

Method 2: Control Samples--Record the number of individuals present (N_i) in representative control areas where the number of breeding pairs (N_p) is known (based on the number of nests) and use this ratio ($k = N_p/N_i$) to calculate the total number of pairs in the colony.

Method 3: Quadrat Samples--Count the number of nests within sample 10 x 10 m quadrats (quadrat size can vary with nest density). The number of quadrats sampled will depend on the colony size and time available. Select quadrats at random, although samples should be as typical of the colony or subareas as possible. Once you know the nest density of these areas, extrapolate the data for the entire colony.

iii. Cliff-Ledge Sites. Make a detailed survey from land and/or sea and count all nests. Only actual nests are to be counted; do not confuse whitewash loafing sites with nests. Usually you can accurately determine the number of nests and consequently the number of breeding pairs.

(b) Counts of Birds in Inaccessible Habitat.

i. Small Colonies. In colonies with sparse vegetation, determine the numbers of birds and location of nests by observing the nesting area through binoculars from a distant vantage point. When vegetation is dense, it may only be possible to count birds roosting or flying in the area.

ii. Large Colonies. If viewing a large colony from a distant vantage point, visually divide the nesting area by natural topographic features into small sections and count the birds in each area. In cases where the size of the colony and/or the terrain do not allow a visual count, take a series of overlapping photographs of the colony to attempt to determine the number of adult gulls present from black-and-white glossy print enlargements.

iii. Aerial Estimation and Photography. Measure gull populations nesting on cliffs and flattish ground by aerial estimation and photography. The procedure is simple; identify species and estimate gull numbers and location of colony as the aircraft passes close to each colony. Photographs can be taken at large colonies to count the number of gulls or to supplement the visual estimate. While the accuracy of visual estimates and those based on the counts of gulls in photographs is low (Kadlec, J.A., and W.H. Drury. 1968), the information does provide some indication of the size of individual colonies and an estimate of the numbers of gulls in geographic regions. Attempts to determine the numbers of breeding pairs from visual counts of individual gulls in attendance at the time of the aerial census are not profitable as the number of birds present at the colony varies within any single day, as well as at different times of the nesting season. Thus, where the relationship of visually estimated and/or counted numbers of gulls to actual numbers of nests is not known, give the estimates as the numbers of birds seen or counted.

(c) Time of Census. The census should be made when most birds are in the late stage of incubation.

f. Black-Legged Kittiwake (Rissa tridactyla).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch maps.

(b) Describe each colony (topography, physical features, etc.).

(c) Make detailed sketch map (to scale) of each colony showing: (1) limits of the colony (using main physical features as landmarks), and (2) outline and estimate of the total nesting area.

(d) Photograph each colony.

(2) Census Techniques (All Habitats). The kittiwake can be censused with relative ease by either making a count of nests from the land and/or sea or using aerial and boat photography. Count only actual nests (structures with sufficient nesting material to retain eggs); do not confuse whitewash loafing sites with nests.

(a) Counts of Nests at the Colony. Make a detailed survey and count all nests. Nest counts can be made from vantage points along the clifftops and/or from the sea below the cliffs. Census large colonies by dividing the total nesting area into small sections using natural topographic features as reference points and counting the nests in each section. The nest count for each region should be the mean value of at least three separate counts.

(b) Counts of Nests on Photographs. Make a reliable census by taking a series of overlapping photographs from either a boat below the cliffs or a light aircraft around the colony. The nests are readily distinguishable on black-and-white glossy enlargements (usually 38 x 36 cm photos) and can be systematically counted to provide a reliable means of monitoring a breeding kittiwake population.

g. Terns (Sterna spp.).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, vegetation, cover, etc.) and divide into subareas according to density if nests are scattered or occur singly or in small groups.

(c) Make detailed sketch map (to scale) of each colony showing: (1) limits of the colony and subareas (use main physical features such as landmarks), (2) estimate of total nesting

area, and (3) composition, single species colony or associated with other terns and/or gulls; if a mixed-species colony, outline the distribution of such species, as very seldom does complete integration occur.

(d) Photograph each colony.

(2) Census Techniques. Keep visits to colonies short (20 minutes) and take special care to avoid unnecessary disturbance. When the colony is large, it may be safe to extend this time period if disturbance is local and birds in adjacent areas remain on their nests. However, birds in small new colonies are very susceptible to desertion after some disturbance. Exercise extreme caution.

(a) Counts of Nests in Accessible Habitat. Direct counts of all nests may be possible at small or scattered colonies, but a sampling procedure may be required at large colonies. When sampling the total nesting area, use one of the following methods, given in descending order of reliability.

Method 1: Line Transect (strip transect)--Place two fixed transect lines, 5 m apart (but quadrat size can vary with nest density) across the colony from edge to edge to ensure total coverage of the colony or subarea. The number of transects will depend on the colony size and time available, although several transects should be done. Permanently mark each transect by placing stakes or some suitable markers at both ends of the line or at regular intervals if the transect is extremely long. Mark points along the transect lines at 5 m intervals and count the number of nests in each 5 x 5 m, or other, quadrat (if transect is very long, select sample quadrats at regular intervals along the lines beginning at the front edge of the colony subarea). Record data for each quadrat separately and in order. Extrapolate an estimate of the total number of nests in the colony from the transect nest density figures.

Method 2: Control Samples--Record the number of individuals present (N_i) in representative control areas where the number of breeding pairs (N_p) is known (based on the number of nests) and use this ratio ($k = N_p/N_i$) to calculate the total number of pairs in the colony.

Method 3: Quadrat Sample--Make direct counts of nests in as many 5 x 5 m, or other, quadrats within each colony or subarea as time permits. Select quadrats at random, although samples should be as typical of the colony or subarea as possible. Once the nest density of these areas is known, extrapolate the data for the entire colony.

(b) Counts of Birds in Accessible and Inaccessible Habitats. Counts of birds are easier than counts of nests. Incubating birds may be counted from a distant vantage point using binoculars without causing disturbance. Where birds are nesting in habitats with uneven terrain or dense vegetation, the best method (at least for common tern, Sterna hirundo and Arctic tern, S. paradisaea)

for obtaining replicable estimates of breeding pairs is to count the number of birds loafing away from the colony and then estimate the number of birds that fly up over the nesting area when flushed, less 10 percent. The census should be made soon after the main peak of egg-laying. Since attendance varies with time of day, time of season, and weather conditions, make a careful note of these parameters at time of census. If time is available and the nesting area accessible, establish control areas within the colony where the number of breeding pairs (N_p) is known (based on the number of nests) and then record the number of individuals present (N_i) in these areas. Use the ratio N_p/N_i to calculate the total number of pairs for all areas censused.

(3) Time of Census. Census during the last half of the incubation period when making actual counts of nests or soon after the main peak of egg-laying for counts of birds.

h. Alcids.

(1) The alcids are a varied and difficult group to census with precision. In general, the number of birds present at a colony varies within very wide limits with time of day, phase of the breeding cycle, and weather conditons. This variation in attendance at the colony severely limits the value of counts unless it is possible to determine associated correction factors, especially for razorbills, murres, and puffins.

(2) The method for calculating the necessary correction factors (k) is given in the individual species accounts. These correction factors vary with time, the nature of the nesting habitat, and weather conditions. Several correction factors may have to be derived where significant differences in census conditions occur. For example, a new correction factor is required for each two-hour period during the day and where the phase of the breeding cycle has changed. Furthermore, it is useful to derive a k value for several control areas under identical conditions (time of day, etc.) to assess variation in k between areas, especially between areas with large (greater than 30 pairs) and small (10 pairs) groups.

(3) In general, razorbill and murre counts are based on egg and/or nest counts alone or, where total egg counts are not possible (e.g., certain murre ledges), by determining the ratio of birds present on control ledges and the total number of eggs and/or young on the same ledges, and using this ratio to calculate the number of pairs for inaccessible colonies. Black guillemot number estimates are from counts of birds seen during a systematic survey of the coast early in the breeding season. Puffins in accessible habitats are censused using grid and line-transect procedures. Details of specific procedures are given in sections h through k of this Technical Note.

i. Razorbill (Alca torda).

(1) Maps and Colony Descriptions.

(a) Mark locations of all nests and/or nesting concentrations on general map.

(b) Make detailed sketch map (to scale) of each nesting area showing exact location of nest sites and limits of the colony based on main physical features of the area.

(c) Photograph the nesting area.

(2) Census Techniques. Razorbills usually nest in scattered pairs, sometimes mixed with murres, on rock ledges, in crevices, under boulders, and in broken cliffs. Birds on ledges are easily observed and counted, but birds nesting in other habitats are often not visible from a distance. In these cases an egg and/or chick count may be the only feasible counting method.

(a) Counts of Birds and/or Eggs and Chicks in Accessible Habitat. Make a direct count of the numbers of birds in the nesting areas and then systematically search the areas for incubating birds, eggs, or chicks to determine the number of breeding pairs. When colonies are too large to search thoroughly or insufficient time is available, establish control areas within the nesting areas and: (1) record the numbers of birds on all nesting areas including those present (N_i in the control areas where the number of breeding pairs (N_p) is known based on the number of eggs and/or chicks); (2) use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all areas censused. As this ratio (N_p/N_i) varies with time and weather conditions, several correction factors (k) may have to be derived where a significant change in census conditions occurs (e.g., time of day--new k value required for each two-hour period--or different phase of breeding cycle, etc.).

(b) Counts of Birds in Inaccessible Habitat. When breeding sites are inaccessible, make direct counts of birds on the nesting areas and nearby locations. Although such counts are inadequate to assess the number of breeding pairs, they may provide a rough index of numbers, especially if the counting procedure is standardized for time of day, phase of breeding cycle, and weather conditions.

(c) Time of Census. Counts should be made in the second half of the incubation period.

j. Common Murre (Uria aalge) and Thick-Billed Murre (Uria lomvia).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, etc.).

(c) Make detailed sketch map (to scale) of each colony showing: (1) limits of the colony based on the main physical features, (2) ledges occupied by birds, and (3) estimate of total nesting area.

(d) Photograph each colony.

(e) Be careful at mixed-species colonies in making species determination and note precisely the limits for each species.

(2) Census Techniques.

(a) Counts of Birds and/or Eggs and Chicks in Accessible Habitat. Although counts of individual birds on bare rock ledges or open nesting sites are relatively easy to make, estimates of the number of breeding pairs are more difficult. At small colonies where the nesting ledges are clearly visible, count the eggs and chicks to give a reliable estimate of the number of pairs. However, when colonies are extremely large and eggs and chicks are not easily seen, the best method is to establish control ledges within the total nesting area, and (1) make direct counts of the numbers of birds on all ledges in the colony (do not correct for birds alighting and departing during the count unless flushing occurred because of observer's presence) including those present (N_i) on the control ledges where the number of breeding pairs (N_p) is known (based on a count of the total number of eggs and/or chicks); (2) use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all colonies censused. Derive a k value (N_p/N_i) for several control areas under identical conditions (time of day, etc.) to assess variation between areas, especially between control ledges with large (greater than 30 pairs) and small (10 pairs) groups.

(b) Counts of Birds in Inaccessible Habitat. At colonies where egg and/or chick counts are not possible, the preferred method is an individual count of adults. Make accurate counts of either all birds present at the colony (small colonies) or the number of individuals in clearly delineated study plots or subdivisions (large colonies) within the colony. Since the necessary correction factors cannot be derived because of the inaccessibility of the nesting ledges, an estimate of the size of the true-breeding population is not possible. However, even though the counts do not represent the entire population, they can be used as an index of colony size with which to repeat censuses made under the same conditions (i.e., time of day, phase of breeding cycle, and weather) and can be compared.

(c) Population Analysis From Photography. Murre populations nesting on steep cliffs or flat-topped surfaces can often be measured and analyzed from aerial photography. Take a series of overlapping photographs during the last half of the incubation period from a light aircraft using a 70-mm camera with standard lenses (100 or 150 mm and black-and-white film [Plus-X] professional) at a distance from the cliff of about 200 to 250 m. Individual birds can be

systematically counted on 18 to 25 cm glossy enlargements using a hand lens (8x) or binocular microscope and plastic grid overlay. The relationship of numbers of murres to actual numbers of eggs and/or chicks (control areas established prior to aerial photography) is known; estimate the number of breeding pairs. If correction factors are not available, the count can still be used as an index of the population (see above). Moreover, this census method provides a permanent and precise record of the distribution and numbers of birds at individual colonies that could be extremely valuable in the future.

(d) Time of Census. Census during the last half of the incubation period.

k. Black Guillemot (Cephus grylle).

(1) Census Techniques (All Habitats).

(a) Nest sites of black guillemots are difficult to count, because they are usually hidden in inaccessible rock crevices or sheer cliffs and boulder-covered beaches. Some nests can be located during the incubation period by watching adult movements in the early morning and evening. During the chick-rearing period watch adults returning with food for their young. However, this method is time-consuming and cannot be easily used over large geographic areas.

(b) The best census method for obtaining standardized counts of breeding populations is to census the coast systematically early on calm mornings (i.e., good weather conditions and no wind) before egg-laying, when pairs are displaying on the sea. Make counts from a boat on the water or from cliff-top vantage points and (1) mark locations of birds seen on the sea along the coastline and record whether solitary or associated with another black guillemot; (2) when a nest site is identified (e.g., bird seen departing from a rock crevice) make a detailed map to show the exact location of the site and describe the physical features of the nesting area for future reference.

(2) Time of Census. Census early in the breeding season before egg-laying (see above).

l. Atlantic Puffin (Fratercula arctica).

(1) Maps and Colony Descriptions.

(a) Mark locations of all colonies on general sketch map.

(b) Describe each colony (topography, physical features, vegetation) and, if necessary, divide each colony into subareas according to burrow density.

(c) Make detailed sketch map (to scale) of each colony showing: (1) limits of the colony (based on main physical features) and subareas (if present), and (2) estimate of total nesting area.

(d) Photograph each colony.

(2) Census Techniques.

(a) Counts of Burrows in Accessible Habitat. Census of puffins presents special problems because they usually nest in burrows in the ground. The best method to determine breeding population size is to count the occupied burrows (burrows with an egg, chick, nest material, defecation stains, etc.). It may be possible to inspect all burrows at small colonies, but these cases are the exception. To determine the abundance of burrows, sample the total nesting area (or subareas) using one of the following methods, which are given in descending order of reliability.

i. Line Transect Method. Place fixed line transects (assign each line a letter--A, B, C, etc.) across the colony from edge to edge to ensure total coverage and to detect changes in numbers at the periphery in future years (e.g., from maritime cliff-edge inland to where burrow density is zero). The number of transects depends on colony size and the time available, though a minimum of three transects comprising at least 30 quadrats is needed. Permanently mark each transect line by placing stakes or some suitable markers at both ends of the line and at regular intervals along it, if the transect is extremely long. Mark points along the line at 5 m intervals and use each point as a corner of a 5 m x 5 m quadrat (quadrat size can vary with burrow density). If transect is very long, select sample quadrats at regular intervals along the line beginning at the front of the colony. Measure the following characteristics within each quadrat: (1) burrow number and status--count all burrows in quadrat (record a hole as a burrow only when it is at least half a meter in length) and determine status of each--active (with egg, chick, nest material, defecation stains, etc.) or inactive (unoccupied); record inaccessible burrows, but note nest status not determined; (2) briefly describe habitat of each quadrat, vegetation, angle of slope, position within colony and/or subarea; (3) distance from front of colony--i.e., record distance from furthest side of quadrat to origin of transect line. Extrapolate an estimate of the total number of breeding pairs in the colony from the line-transect and occupied-burrow density figures.

ii. Subarea Sample Method. Make direct counts of burrows in as many 5 x 5 m (or other) quadrats within the defined subareas as time permits. Select quadrats at random, though samples should be as typical of the subarea as possible. Record with the line-transect method: (1) burrow number and status, (2) habitat description, (3) distance from front of colony.

(b) Counts of Burrows in Rock Scree or Boulders. It is often difficult to distinguish a burrow from a natural cavity in this habitat, but careful examination of holes for signs of excavation and other nesting activities does make it possible to records accurately

the number of burrows. Quadrat size may have to be adjusted to the local conditions in rocky habitat where boulders are very large or nest density exceptionally low.

(c) Counts of Birds in All Habitats.

i. There is no method sufficiently accurate to determine or estimate population size from counts of birds standing on the colony during one day. Puffins not only display large daily and seasonal fluctuations in colony attendance but also vary in a quasi-cyclical fashion through most of the breeding cycle, the length of which appears to differ between colonies. This means that counts made when peak numbers are present might be more than 100 times the counts made at the same time two days later.

ii. Therefore, if counts of birds must be used to census the colony (e.g., where the terrain is difficult or inaccessible), make systematic counts of the number of birds standing on the colony through the day (i.e., morning: early, mid, and late; afternoon: early, mid, and late; and evening) from a hidden viewpoint for several consecutive days (total days required depends on features of the cycle; length and phase when census initiated). Count them early in the breeding cycle; the ideal time is during the prelaying period. Use the count when peak numbers were present as an index of population size.

iii. When accessible colonies cannot be censused by burrow count methods, lack of time or difficult terrain, make a reliable estimate of population with the following technique: (1) establish control areas (areas within the colony where the number of breeding pairs (N_p) is known, based on number of burrows with eggs or young); (2) make a direct count of the number of birds standing on the colony (or representative sections) when peak numbers are present (determine peak using method described above) which includes individuals (N_i) on the control areas; (3) use this ratio ($k = N_p/N_i$) to calculate the number of pairs for all colonies censused.

Note: It is essential to establish control areas in all habitats occurring within the total nesting area (e.g., maritime slope, flattish ground, etc.) as the relationship between the distribution of adults and the distribution of nest sites differs between habitats.

(3) Census Time. Counts of birds should be done early during the prelaying period. Estimate burrows from late in incubation onward, though standardize the census time at each colony. Take special care during the incubation period as extended disturbance will cause nest desertion.

Recording Data

A. Several examples of forms are included in this Technical Note that may be used for recording field data as it is collected for different groups of birds or when using different types of surveys.

Different forms for recording data may be developed by the states/districts where desirable to include additional or different types of information.

B. Regardless of the field form utilized for data recordation, all information on species occurrence, unique features, etc., should be transposed onto forms 6602-1 (Animal Species Occurrence by Habitat Site) and 6602-2 (Special Habitat Feature) as required in BLM Manual Section 6602, Integrated Habitat Inventory and Classification System.

C. Where standard procedures are being utilized nationwide for accumulating data for national trends, such as the Cooperative Breeding Bird Survey of North America and the Christmas Bird Counts, district/area biologists should follow the prescribed procedures and forward their data to the appropriate central facility.

Analyzing Survey and/or Census Data

All district/area surveys should be tabulated, analyzed, reported, and appropriately filed for future reference. A major value of any survey is as baseline data which can be used in later years for comparative purposes in determining the impacts of land use actions and human disturbances on bird populations and species composition. Data should be filed so as to be understandable and usable by district personnel.

Reliability of Survey and/or Census Data

The surveying or censusing of any animal population is difficult at best. Reliability of any census is directly proportional to the energy and time expended in acquiring the data. A bird species occurrence survey does not require as many counts or "runs" through a plot or along a transect as does a bird density survey. The specific objective for the survey will dictate choice of time, manpower, and system to be utilized. Reliability is a direct consequence of these factors.

Bird Habitat Condition and Trend

A. The condition and trend of bird habitat varies throughout the West and the nation, depending on species and adaptation to human disturbances. Riparian habitats are rapidly declining in some areas with subsequent, and sometimes critical, reductions in populations of certain species. Most riparian species are directly tied to this environment and disappear from the area when their riparian habitats are destroyed. Species involved include several raptors (including the black, zone-tailed, and gray hawks; merlin, bald eagle, and osprey).

B. Wetlands continue to be drained throughout the nation, causing losses not only of waterfowl, but also of the closely associated marsh and shore birds dependent on those areas for their life activities. Aquatic and riparian habitats must have the highest priority for protection and management on public lands.

C. Certain terrestrial habitats are also critically necessary to some species of birds. A well-known example is the Kirtland's warbler that requires a specific seral stage of southern pine, called "jack pine" for its reproduction. Pileated woodpeckers require certain species of trees of certain size and heights for their nest sites. Spotted owls require old growth forests for their nests and prairie falcons require cliffs for nesting. Sage grouse are habitat specific to sagebrush, with certain forb and grass composition in the understory being preferred. As greater knowledge is attained through research and individual observations, undoubtedly a large number of bird species will be found to be more specifically tied to certain vegetative structure and composition than is presently known.

D. Bird composition and density change with each new seral stage that develops in a plant community. The desirability of such changes is affected by esthetics, economics, ecologic concerns, and other factors. The overall effects of bird population and species changes are unknown, especially on a West-wide or nationwide basis, but drastic changes in local populations and species are not uncommon. As increased efforts are provided in bird surveying and censusing, the full impacts of changes in avian habitats will gradually become recognized.

GLOSSARY OF TERMS

-A-

abiotic: non-living; concerning basic elements and compounds of the environment.

accipiters: birds of prey that generally possess short wings and long tails well adapted to highly maneuverable flight. This group preys largely on small birds and includes the goshawk, Cooper's hawk, and sharp-shinned hawk.

aquatic: maintained in water; regarding flora and fauna which live entirely within or depend on water media for their major life functions. (Does not include shore birds, waterfowl, beavers, etc.)

association: an ecosystem described primarily by potential natural vegetation according to A. W. Kuchler. Associations differ from biomes by being intraregional (limited by physiographic boundaries) and of a much greater homogeneity. Associations are named usually from two or more dominant plant species which are physiognomically similar and ecologically related.

avian: term synonomous with birds.

-B-

Beaufort scale: British code accepted internationally for indicating wind velocity, with a range of 0 to 5.

biotic: relating to life, that which is living, both fauna and flora of a given geographic location.

buteos: birds of prey including the large soaring hawks which have large wings adapted for soaring and hunting large areas with minimum effort.

-C-

census: the observing, either visually or aurally, and recording of species and numbers of birds (or other animals) in either a colony or in a particular area of habitat.

coefficient of detectability: the proportion of the total population which the observer can detect, either visually or aurally, while conducting a census.

colonial: birds (or other animals) that are socially tolerant of each other and which habitually nest (or create burrows, etc.) in close proximity to each other, such as herons, cliff swallows, prairie dogs, etc.

critical habitat: any land, air, or water area, including any elements thereof, which the Secretary of the Interior or the Secretary of Commerce has determined, or may determine, to be essential to the survival of wild populations of an endangered or threatened species or to be necessary for its recovery to a point at which the measures provided pursuant to the Endangered Species Act are no longer necessary.

-D-

declining species: any bird or other animal species whose numbers are declining for any reason, but has been declining more in recent years because of destruction of habitat.

dominance: the influence or control of existing biotic conditions exerted by plant species or groups. This influence may be manifest be density factors (number, coverage) or by size, vigor, etc.

-E-

ecological niche: that particular portion of habitat that is occupied and needed for survival by a specific species of bird or other animal. Refers to any particular portion of an animal's requirements, including nesting or denning habitat, food, space, water, roosts, or other factors.

ecosystem: a geographically definable system of interrelating biotic and abiotic components. Ecosystems exist at numerous hierarchical levels and are characterized by increasing homogeneity at progressively lower levels of the hierarchy.

ecosystem determinant: an abiotic or biotic factor which characterizes an ecosystem, including its vegetative aspects, landforms, slope, etc.

ecotone: an area of transition between two or more diverse habitat sites or associations. Example: that area between forest and grassland.

endangered species: any species of plants or animals in danger of extinction throughout all or a significant portion of its range.

eyrie: usually the specific nesting site of one of the birds of prey, i.e., the nesting ledge, cavity or tree in which the nest is built (or a scrape, in the case of falcons).

-F-

falcons: birds of prey that possess long pointed wings and streamlined bodies which permit extremely rapid flight in open country. Their speed allows them to capture birds on the wing.

falconry: the practice of capturing birds of prey and training them to capture wild game for the trainer. This sport has been practiced for thousands of years.

-G-

"greenery": the practice of nesting birds of prey of placing green sprigs, branches, leaves, etc., on their nests at any time from beginning to end of the nesting period. An active nest can usually be identified by this fresh green material on the nest.

-H-

habitat site: a local ecosystem influenced by regional physiography and intraregional associations but defined very specifically by existing vegetation and local landform. The habitat site is the most homogeneous and specific member of the hierarchical scheme of ecosystems represented in BLM's Integrated Habitat Analysis System.

hierarchical: relating to the classification or relationship in an order of stratification from the most homogeneous to the least.

homogeneous: the quality or state of being a single type; showing little or no variation.

-J-

juxtaposition: the act or an instance of placing two or more objects in close spatial relationship.

-N-

national resource lands: these are the lands under the administration of the Bureau of Land Management; they were formerly known as the public domain, and are now referred to as public lands.

nocturnal: the habit of being active during the hours of darkness. Nocturnal birds include the owls, nighthawks, poor-wills, etc.

nongame: species of animal and bird life that are not classified as game by the State wildlife agencies. Some nongame species are protected by State and Federal law, which include the eagles, hawks, and owls. Others have no protection, including the prairie dogs (except the Utah prairie dog), ground squirrels, starlings, and English sparrows.

-P-

passerines: birds, including most of the small perching birds, such as the sparrows, finches, flycatchers, bluebirds, and most other small terrestrial species.

pelagic: the birds of the open sea that are frequently found at considerable distances from the shore.

physiognomy: external aspect; characteristic or peculiar contour; inner character or quality as revealed outwardly.

physiographic region: an ecosystem of regional proportion described primarily by abiotic components, particularly the type of landform and soils that give it its characteristic aspect (e.g., mountain, plateau, basin, plains, etc).

premature fledging: the act wherein a young bird attempts to fly from its nest before it is physically or mentally ready. Such early fledging is frequently induced by human disturbance, especially when the birds are suddenly or unexpectedly startled.

-R-

raptor: the term that includes all of the birds of prey, or those that normally kill their own prey.

relative abundance: the relative abundance of a particular species is simply the proportion of that species observed during a transect to the total number of birds of all species detected on the transect. Percent relative abundance is calculated with the following formula:

$$\% \text{ RA} = \frac{\text{Density of a given species}}{\text{Total density of all species}} \times 100$$

riparian habitat: the vegetation portion of the habitat associated with wetlands, such as streams, rivers, lakes, ponds, and other bodies of water. The habitat may be considered as transitional between habitats and, while usually associated with water courses, the habitat may extend onto upland areas for considerable distances. Riparian vegetation, unlike that of most wetlands, is highly variable and often ranges from water-loving forms (phreatophytes or hydrophytes), such as sedges, through terrestrial forms, such as cottonwoods and willows.

-S-

seabirds: birds commonly associated with ocean shores and the ocean areas contiguous to the shores. These birds usually nest on cliff lines or islands in relatively close proximity to the mainland.

sensitive species: birds (or other animals) whose populations are not yet officially listed as endangered but which are under study to determine their real status. These are species that may be highly sensitive to human disturbance and whose numbers could seriously decline if continued reductions or modifications in their habitat continue to cause stress on the birds or otherwise disturb them unduly during the nesting process or during other critical phases of their life cycles.

special habitat feature: a specific component of a habitat site requiring individual consideration, including geological anomalies, aquatic situations, or other unique structures (cliffs, caves, sand dunes, volcanic cones, etc.). Special habitat features may have positive or negative values for particular species.

species: any group of individual birds or other animals (including full species, subspecies, and populations) that live in common spatial arrangement and interbreed.

spot map: the procedure whereby every individual observed during a census is mapped as to observed location. Thus, the territories of individual males and/or female birds are determined. Territorial birds confine themselves to a specific restricted area from which they forcefully eject other birds of their own species. Once all territories are determined, the total number of breeding birds in an area can be calculated.

standard habitat site: a grouping of habitat sites having similar vegetation and local landforms.

survey: the process of locating active colonies or groups of nesting birds or other animals, or the actual nesting sites of birds of prey or other birds. Contrast with censusing which is the process of actually counting individuals present at a colony of birds within a specified area (or other animals living within any defined geographic area).

-T-

terrestrial: relating to those species, both flora and fauna, that are primarily restricted to the land and/or air.

territorial: birds and other animals that defend their chosen nesting, breeding, or feeding habitat from other animals of their own species (and sometimes other species) during some period of the year. It is the area in which practically all life activities occur for a particular pair of breeding birds.

threatened species: any species which is likely to become endangered, because of adverse influences, throughout all or a significant portion of its range within the forseeable future.

-V-

vegetative aspect: the visual first impression of vegetation relating to the nutritive and growth functions (forms) of plant life, as seen at a particular time or from a specific point.

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